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Rev. 07/10/02

SOLUTIA

SAUGET AREA 1 TSCA CONTAINMENT CELL DESIGN REPORT SOLUTIA INC. CAHOKIA, ILLINOIS

Prepared for:

Solutia Inc.
575 Maryville Centre Drive
St. Louis, MO 63141

Prepared by:

URS
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C100004051.00

April 2. 2001

Revision

SOLUTIA

Applied Chemistry, Creative Solutions

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March 30, 2001

Kevin Turner-Environmental Scientist, OSC (3 copies)
U. S. Environmental Protection Agency
8588 Rt. 148
Marion, IL 62959

Re: **Sauget Sites Area I - May 31, 2000 Unilateral Administrative Order**
Docket No. V-W-99-C-554
Dead Creek Sediments & Soils Removal / Containment

- **Time Critical Removal Action Work Plan**
- **Revised Appendix D, "Containment Cell Design Report"**

Dear Mr. Turner,

On May 31, 2000 the United States Environmental Protection Agency ("U. S. EPA") issued a Unilateral Administrative Order ("Order") to Monsanto Company and Solutia Inc. ("Solutia") requiring removal of soils and sediments from Dead Creek and placement within a containment cell. On June 30, 2000 Solutia submitted for U. S. EPA's approval, a Time Critical Removal Action Work Plan ("TCRAWP") pursuant to the Order and containing a draft "Containment Cell Design Report" as Appendix D to the TCRAWP.

The U.S. EPA, Illinois EPA, Illinois DNR and U.S. Fish and Wildlife Service ("Agencies") have reviewed the TCRAWP submittal. After a series of Comments from the Agencies, discussion meetings and Responses to Comments by Solutia, the Agencies and Solutia came to resolution on all of the Agencies' comments. On March 5, 2001, conditional approval of the TCRAWP and containment cell design was received from the U. S. EPA. The approval was subject to the Agencies' concurrence that the final TCRAWP Containment Cell Design Report accurately incorporated all of the agreements generated by the Comments / Response-to-Comments process. It is Solutia's intent and belief that this submittal of the revised Appendix D, "Containment Cell Design Report" to the June 30, 2001 TCRAWP, incorporates all agreed-to modifications and additions to the containment cell design.

On the basis of the conditional March 5, 2001 U. S. EPA approval of the TCRAWP and containment cell design and in the interest of a timely and cost effective response, Solutia has in good faith let a contract for construction of the cell. The selected contractor is presently setting up site operations and mobilizing equipment and manpower to the field in anticipation of the Agencies' final approval of the TCRAWP. Construction of the cell will begin immediately upon receipt of final approval.

Solutia appreciates your prompt review and receipt of final approval. As we have discussed, it is critical from both a cost and schedule standpoint that construction of the cell begin without delay in order to fully utilize the 2001 construction season.

Sincerely,

D. M. Light
Project Coordinator
Solutia Inc.

cc: (w/enclosure)

Robert Watson - IEPA
Linda Tape, Esq. - Thompson Coburn
Mike Henry - IDNR
Kevin de la Bruere - U.S. F&WS

cc: (w/o enclosure)

Thomas Martin, Esq. - USEPA
Michael McAteer - USEPA

In accordance with the Illinois Statutes, the attached Sauget Area 1 TSCA Containment Cell Design Report for the Solutia Inc. Sauget Area I Superfund Site located in Cahokia, Illinois, was prepared by others under the supervision and control of the undersigned Illinois Registered Professional Engineer.

The attached final design report, specifications and construction quality assurance documents were prepared by URS Corporation Southern (URS) within the limits prescribed by our client using standard engineering procedures in a manner consistent with the skill and level of professional care exercised by other professionals practicing in the same locality at the same time under similar circumstances. Information provided to URS by client representatives, agents and other consultants has been accepted in good faith and is assumed to be true and accurate.

WM. L. DURBIN
NO. 62-040635
REGISTERED PROFESSIONAL ENGINEER
Jr
ILLINOIS

Signed:
William L. Durbin, P.E.
Registered Professional Engineer
Illinois License No. 62-040635

Date:
March 30, 2001

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Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
PART I: RESPONSE TO COMMENTS					
1	Comment 14 : Appendix 7, Section 4, Page 4-3, Subsection 4.1.3	Please add a sentence to the text which states the depth the gas vents will penetrate the waste material.	A sentence will be added at the end of Paragraph 2, Section 4.1.3 - Load on Lining System and incorporated in the Work Plan as follows: The vent system will allow generated gas to exit the cell without pressure build up. Gas vents will penetrate a minimum of 18 inches into the compacted sediments.	Paragraph 2, Section 4.1.3	
2	Comment 15: Appendix 7, Section 4, Page 4-13, Subsection 4.5.3	Will any type of high water/leachate alarm be installed in the sump area: If not, now will Solutia check the leachate head level to determine when it is time to pump? Please elaborate within the text.	Paragraph 3 of Section 4.5.3 will be rewritten as shown below and incorporated verbatim into the Work Plan. The HELP model results indicate that leachate production will be minimal after the cover system is in place. The transmissivity of the sand, gravel and geonet layers are adequate to rapidly transmit the leachate to the collection sump. Leachate level in the sump will be monitored with a high level alarm. When high level conditions occur, two actions will occur: 1) an alarm light visible from Judith Lane will be activated, and 2) an auto-dialer will be activated and notify the operator of the high level condition. Any liquids found in the collection piping will be removed at that time and placed in drums or tanks for disposal.	Added new Paragraph 4, Section 4.5.3	
3	Comment 16: Appendix 7, Section 5, Page 5-5, Subsection 5.4.4	Where does the storm water flow after it has traveled down the paved downchute and into the stilling basin? It appears from the drawing Cover System Plan, Sheet C1.5 that nothing is contemplated. I think it is best to direct the surface water away from the containment cell and either into Segment B or a storm sewer as soon as possible. Please indicate within the text and if appropriate alter the drawing Cover System Plan, Sheet C1.5.	Paragraph 3 of Section 5.4.4 Drainage and Erosion will be modified as follows and included in the Work Plan verbatim: The downchute and stilling basin are designed to handle 14 cfs peak flow. A drainage swale will be constructed north of the containment cell to route stormwater from the stilling basin to Creek Segment B which will be used to provide the stormwater detention required by local and state regulation. The stormwater calculations for the cover system are provided in Appendix D of the Design Report. The revised Drawing C1.5 is included as Attachment 2.	Section 5.4.4	Replaced by Response to Part III Comments

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4	**Comment 17**: Appendix 17, Figures 4-8 and 4-9:	Please add detail drawings for both the primary and secondary riser which shows a cross section of the sump and riser as the riser angles up the slope to the top of the containment cell.	Drawings showing cross sections of the sump and riser as the riser angles up the slope of the containment cell will be prepared as included below and included in the Figure's section of Appendix 7. These drawings are included as Attachment 3 of this response to comments document.	Added Figures 4-10 through 4-16 to the report	
5	**Comment 18**: Appendix E:	At the bottom of page 01010-4 the reference to the Pensacola Plant should be changed.	The last paragraph on Page 01010-4 will be revised as follows and incorporated into the Work Plan: Contractor and all employees, subcontractors, supporting firms and incidental labor shall meet Solutia's minimum safety requirements.	Specification section changed	

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PART II: RESPONSE TO COMMENTS (NOVEMBER 3, 2000)						
6	**Comment 1**: Response to Comment	The response to these comments needs to include a list of item-by-item responses that indicates how each comment was addressed and where the Design Report was revised in response to each comment.	This Response to Comments (Part II) Document is intended to address this comment. A response is given for each comment along with a commitment to incorporate the response into the Design Report when it is accepted by the Agency.		Added comments	Included as Section 1 of the Final Design Report
7	**Comment 2**: Format of Design Report and Requirements in Exhibit 2	In order to demonstrate that all of the requirements in Exhibit 2 of the UAO are met, the Design Report needs to include a table that clearly cross references the requirements in Exhibit 2 with the various Sections, and appendices in Appendix 7.	The following table will be incorporated into Section 2.0, Introduction, of the Design Report to demonstrate that all of the requirements in UAO Exhibit 2 are addressed.			
			Exhibit 2	**Design Report**		
			1. Design, Construction and Operation Requirements for Containment Cell			
			a. Sediment Description	Note 1	Section 2	
			b. Liner System			
			- Liner System Description	Section 4.1.1 Liner System Description		
			- Liner System Location Relative to High Water Table	Note 2		
			- Loads on Liner System	Section 4.3.2 Synthetic Liner Strength		
			- Liner System Coverage	Section 4.1.4 Lining System Coverage		
			- Liner System Exposure Prevention	Section 4.1.5 Lining System Exposure		
			c. Foundation			
			- Foundation Description	Section 3.0 Site Characterization		
			- Subsurface Exploration Data	Section 3.3 Subsurface Conditions		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response		Design Report Section(s) Modified	Comments
			- Laboratory Testing Data	Section 3.2 Geotechnical Testing		
			d. Engineering Analysis			
			- Settlement Potential	Section 4.2.1 Settlement Potential		
			- Bearing Capacity	Section 4.2.2 Bearing Capacity		
			- Stability of Landfill Slopes	Section 4.2.3 Cell Slope Stability		
			- Potential for Excess Hydrostatic or Gas Pressure	Section 4.2.6 Potential Excess Pressure		
			e. Synthetic Liners			
			- General Information	Section 4.3.1 General Information		
			- Synthetic Liner Compatibility Data	Note 3		
			- Synthetic Liner Strength	Section 4.3.2 Synthetic Liner Strength		
			- Synthethic liner Bedding	Section 4.3.3 Synthetic Liner Bedding		
			f. Geocomposite Liner (GCL)			
			- Description	Section 4.4.1 General Information		
			- Material Testing Data			
			- GCL Liner Compatibility Data	Note 3		
			- GCL Liner Strength	Section 4.4.2 GCL Strength		
			g. Liner System, Leachate Collection and Detection System			
			- System Operation and Design	Section 4.5.1 System Operation & Design		
			- Equivalent Capacity	Section 4.5.2 Equivalent Capacity		
			- Grading and Drainage	Section 4.5.3 Grading and Drainage		
			- Maximum Leachate Head	Section 4.5.4 Maximum Leachate Head		
			- System Compatibility	Note 3		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response		Design Report Section(s) Modified	Comments
			- Stability of Drainage Layers	Section 4.5.5 Stability of Drainage Layers		
			- Strength of Piping	Section 4.5.6 Strength of Piping		
			- Prevention of Clogging	Section 4.5.7 Prevention of Clogging		
			h. Liner System, Construction and Maintenance			
			1. Material Specification	Section 6.1.1 Material Specifications		
			- Synthethic Liner Specifications			
			- GCL Liner Specification			
			- Leachate Collection/ Detection System			
			2. Construction Specifications	Section 6.1.2 Construction Specification		
			- Liner System Foundation			
			- GCL Liner			
			- Synthetic Liner			
			- Leachate Collection/ Detection System			
			i. Construction Quality Control Program	Appendix F and Appendix G		
			j. Maintenance Procedures for Leachate Collection/ Detection System	Note 4		
			k. Liner Repairs During Operation	Specification 02244		
			l. Run-off Control Systems			
			- Design an Performance	Section 5.5.1 Design and Performance		
			- Calculation of Peak Flow	Section 5.5.1.1 Calculation of Peak Flow		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response		Design Report Section(s) Modified	Comments
			- Management of Collection and Holding Units	Section 5.5.1.2 Collection & Holding Units		
			- Construction	Section 5.5.1.3 Construction		
			- Maintenance	Section 5.5.1.4 Maintenance		
			- Control of Wind Dispersal	Section 5.6 Control of Wind Dispersal		
			2. Closure and Post-Closure Requirements			
			a. Closure Requirements			
			1. Closure Plans	Section 5.1 Closure Plans		
			2. Closure Performance Standards	Section 5.2 Performance Standard		
			3. Cover Design	Section 5.3 Cover System Description		
			4. Minimization of Liquid Migration	Section 5.4.2 Minimization of Migration		
			5. Maintenance Needs	Section 5.4.3 Maintenance Needs		
			6. Drainage and Erosion	Section 5.4.4 Drainage and Erosion		
			7. Settlement and Subsidence	Section 5.4.5 Settlement & Subsidence		
			8. Freeze/Thaw Effects	Section 5.4.6 Freeze/Thaw Effects		
			b. Post-Closure Requirements	Note 5		
			1. Post-Closure Plan			
			2. Inspection Plan			
			3. Post-Closure Monitoring Plan			
			4. Post-Closure Maintenance Plan			
			5. Notice in Deed and Certification			

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			Notes: 1) Time Critical Removal Action Work Plan, Section 3.0 Sediment Chemical Analyses and Bioassays 2) Time Critical Removal Action Work Plan, Section 2.8, Groundwater Levels 3) Compatibility tests are underway and scheduled to be completed in late December 2000. 4) System is designed to minimize maintenance so description of maintenance is needed. 5) Post-closure will be addressed in the O&M Plan which is due 60 days after completion of cell construction.		
8	**Comment 3**: Figures in Appendix 7	If the Figures after 5-6 are redundant/extras, they should be removed from the report. If they refer to specific design issues not shown in the other figures, they need to be specifically referenced in the narrative portion of the design report.	Design drawings will be removed from the Design Report.	Extra figures were removed	
9	**Comment 4**: Previous Excavation of the Site	Section 4.2.1 includes the statement "portions of the site have apparently been previously excavated for borrow material." These excavated areas need to be identified on a scale topographic map of the site. The document needs to indicate if these excavated areas were filled in. If they were backfilled, the fill material needs to be identified and possibly sampled to determine its chemical and engineering properties.	Paragraph 3 of Section 4.2.1, Settlement Potential, reads as follows: "The proposed containment cell will be founded on the existing foundation soils between 397 and 407 ft elevation. The ground surface elevation at the proposed site was apparently about 407 ft. Portions of the site have been previously excavated for borrow fill." Nothing is known about the excavation history of the site. When writing this paragraph, the author was speculating as to the cause of a slope present on the western edge of the containment cell area. This slope could be natural or it could be man made. For this reason, the last two sentences of this paragraph are speculative and will be removed from the Design Report.	Paragraph 3, Section 4.2.1	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
10	Comment 5: Section 4.1.1 Liner System Description	The document needs to identify the manufacturer, product name, and include technical data sheets for all components proposed for use in the bottom, side, and cover systems. Wording which will allow the use of materials from a different manufacturer can also be included in the document provided the alternate material has equivalent, or better, characteristics/properties to the one identified in the Design Report.	Geosynthetic manufacturers and products will be identified in the Design Report. Manufacturers technical data sheets will be included for all geosynthetic components including geomembrane, GCL, geotextile, geonet and geogrid. These cut sheets are included as Attachment 1 of this Response to Comments Document and will be included as Appendix H of the Design Report. Paragraph 1, Section 4.1.1, Description, of the Design Report will be amended as shown below: "The bottom liner system for the proposed containment cell will be a multi-component composite lining with leachate collection and leak detection layers. Figure 4-1 shows the proposed configuration of the bottom lining system. A description of the components is provided below in a bottom to top order. **HDPE membrane will be manufactured by GSE, Serrott or equivalent. Geotextile will be manufactured by Mirafi or equivalent. Geonet and geonet will be manufactured by Tenax or equivalent. GCL will be manufactured by CETCO, GSE, Serrot or equivalent. Manufacturers technical data sheets for these geosynthetics are included in Appendix H.**"	Section 4.1.1	Added Appendix H

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
11	**Comment 6**: Section 4.1.1 Liner System Description	A geotextile needs to be placed between the capillary break layer (gravel) and subgrade for the GCL. The geotextile needs to be thick enough (and strong enough) to prevent the six-inch fill layer from being pushed down into the gravel. The document needs to provide the manufacturer, product name, and specifications of this geotextile. It also needs to compare these specifications to the conditions it will be exposed to in the liner system and demonstrate the geotextile will function as intended.	A geotextile will be placed between the capillary break layer and the GCL bedding layer to prevent intrusion of the latter into the former. Strength calculations are included as Attachment 2 of this Response to Comments Document and will be included in Appendix C, Liner System Component Design, of the Design Report. Figures 4-1, 4-2 and 4-8 of the Design Report will include this geotextile. Figures 4-1, 4-2 and 4-8 are in Attachment 3 of this Response to Comments Document. Paragraph 4 of Design Report Section 4.1.1 will be revised as shown below: "**After placing a geotextile on top of the capillary break layer**, a 6-inch native fill layer will be pushed and tracked into place over the capillary break layer. ..."	Section 4.1.1	
12	**Comment 7**: Section 4.1.1 Liner System Description	Uncompacted native fill or sand (in the case of the cover system) will not form an adequate subgrade for the GCL. The subgrade under the GCLs in the bottom liner, on the side slopes, and in the cover system all need to be constructed of soils that can be formed into bedding layers capable of supporting and protecting the GCL and other layers in the liner system during the construction process. For more specific requirements regarding the density, moisture, and gradation specifications required for the GCL bedding layer, refer to the comments on the Earthwork Specification 02200 in Appendix E.	A wide range of soils, including sand, can be used as bedding material for geosynthetics. Specification 02200 - Earthwork, included in Attachment 4 of this Response to Comments Document, will be used for the geosynthetic bedding layers in the liner system. It will also be included in Appendix E, Technical Specifications, of the Design Report. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.	Section 4.1.1 (Paragraphs 6 and 8)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
13	**Comment 8**: Section 4.3.1 Synthetic Liners	The description of the HDPE geomembrane states that it will be smooth (not textured). It is recommended that a textured geomembrane be used to improve the structural stability of the liner systems. If the geomembrane will be textured, the asperity height (height of the textured surface) also needs to be indicated.	Textured geomembrane will be used in liner system construction. Manufacturer's technical data sheets are included in Attachment 1 of this document and they will be included in Appendix H of the Design Report.	Paragraph 1, Section 4.3.1	Secondary HDPE liner will be textured
14	**Comment 9**: Section 4.1.1, Synthetic Liners	The design report needs to demonstrate that the 12 inch soil layer in the primary liner system will meet the HDPE geomembrane manufacturer's bedding layer specifications. As part of this demonstration, the design report needs to identify the soil type and grain size distribution of this 12-inch soil layer. This layer should be a clayey soil compacted to at least 95% of the Standard Proctor Density using ASTM D-689 and have a moisture content at or near optimum.	A wide range of soils, including sand, can be used as bedding material for geosynthetics. Specification 02200 - Earthwork, included in Attachment 4 of this Response to Comments Document, will be used for the geosynthetic bedding layers in the liner system. It will also be included in Appendix E, Technical Specifications, of the Design Report. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.	Section 4.1.1 (Paragraphs 6 and 8)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
15	**Comment 10**: Section 4.1.1, Synthetic Liners	The description of the primary liner states that the 12-inch soil layer will not be installed on the side slopes. The design report needs to indicate why the design on the side slopes is different from the bottom liner design and provide justification for this design change. It is recommended that the clay layer in the primary liner system continue up the side slope.	A 12-inch soil layer can not be constructed on the side slopes of the containment cell. Placing sediments directly on the side slope liner does not create a problem unless there are materials present that could puncture the liner system. To insure that the side-slope liner system is not punctured, excavated sediment in contact with the cell side slopes will be screened to remove material larger than 2 inches including sticks, trash and sharp objects. While spreading sediments in the bottom of the cell, a bank of screened sediment will be placed two to three feet high and two to four feet thick at the toe of the slope. This bank of screened sediment will protect the side-slope liner system. When the fill reaches the height of this bank, another one will be constructed of screened sediment at the toe of the slope to protect the side-slope liner system. Section 5.0 of the Time Critical Removal Action Work Plan will be modified by adding the paragraph shown below. This will ensure that sediments placed against the cell side slopes will not puncture the liner system. To insure that the side-slope liner system is not punctured, excavated sediment in contact with the cell side slopes will be screened to remove material larger than 2 inches including sticks, trash and other sharp objects. While spreading sediments in the bottom of the cell, a bank of screened sediment will be placed two to three feet high and two to four feet thick at the toe of the slope.	Specification 02225 (Section 3.3.F)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			This bank of screened sediment will protect the side-slope liner system. When the fill reaches the height of this bank, another one will be constructed of screened sediment at the toe of the slope to protect the side-slope liner system. This paragraph will be added at the end of Section 5.0, Sediment Handling, Treatment and Dewatering Plan. Specification 02225, Section 3.3.F of the Design Report will be modified as shown below. This will ensure that sediments placed against the cell side slopes will not puncture the liner system. F. Place **screened** sediment **on the** side **slope** lining **to a height of 2 to 3 ft. above the toe of the slope and to a thickness of 2 to 4 ft. Screen these sediments to remove materials 2 inches and larger including sticks, trash and other sharp objects.**		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
16	**Comment 11**: Section 4.1.1 Synthetic Liners	The narrative states (and Figure 4-2 shows) that wastes will be placed directly on top of drainage composite on the side slopes. This is significantly different from the design of the leachate collection system on the bottom liner. The design report needs to indicate why the design of the leachate collection system on the side slopes is different from the bottom liner design and provide justification for this design change. The 6-inch sand protective layer over the geotextile needs to continue up the side slopes.	A 6-inch sand layer can not be constructed on the side slopes of the containment cell. Placing sediments directly on the side slope liner does not create a problem unless there are materials present that could puncture the liner system. To insure that the side-slope liner system is not punctured, excavated sediment in contact with the cell side slopes will be screened to remove material larger than 2 inches including sticks, trash and sharp objects. While spreading sediments in the bottom of the cell, a bank of screened sediment will be placed two to three feet high and two to four feet thick at the toe of the slope. This bank of screened sediment will protect the side-slope liner system. When the fill reaches the height of this bank, another one will be constructed of screened sediment at the toe of the slope to protect the side-slope liner system. Section 5.0 of the Time Critical Removal Action Work Plan will be modified by adding the paragraph shown below to the end of this section. This will ensure that sediments placed against the cell side slopes will not puncture the liner system. To insure that the side-slope liner system is not punctured, excavated sediment in contact with the cell side slopes will be screened to remove material larger than 2 inches including sticks, trash and other sharp objects. While spreading sediments in the bottom of the cell, a bank of screened sediment will be placed two to three feet high and two to four feet thick at the toe of the slope.	Specification 02225 (Section 3.3.F)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			This bank of screened sediment will protect the side-slope liner system. When the fill reaches the height of this bank, another one will be constructed of screened sediment at the toe of the slope to protect the side-slope liner system. Specification 02225, Section 3.3.F of the Design Report will be modified as shown below. This will ensure that sediments placed against the cell side slopes will not puncture the liner system. F. Place **screened** sediment **on the side slope** lining **to a height of 2 to 3 ft. above the toe of the slope and to a thickness of 2 to 4 ft. Screen these sediments to remove materials 2 inches and larger including sticks, trash and other sharp objects.**		
17	Comment 12: Section 4.1.2 Liner System Relative to High Water Table	The report needs to include a geologic cross section that shows the elevations of the landfill, the formations under the unit, and the seasonal fluctuations in the water table.	A geologic section is included in Attachment 5 of this document and will be included as Figure 3.4 of the Design Report.	Added Figure 3-5	
18	Comment 13: Section 4.1.3, Loads on the Liner System	Calculations supporting the statements and conclusions need to be included in the design report and referenced in the narrative of Section 4.1.3. Each layer in the liner system needs to be considered in the calculations, not just the HDPE geomembrane.	Liner system load calculations are included as Attachment 6 of the Response to Comments Document and will be included in Appendix C, Liner System Component Design, of the Design Report.	Added calculations to Appendix C	
19	Comment 14: Section 4.1.4, Figure 4-7, Liner System Anchor Detail	The design report needs to justify the design of the anchor shown in Figure 4-7. The report needs to include estimates of the forces the landfill will exert on the liners, and calculations that show that the anchor will hold the liner in place.	Anchor system design calculations are included as Attachment 7 of the Response to Comments Document and will be included in Appendix C, Liner System Component Design, of the Design Report.	Added calculations to Appendix C	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
20	**Comment 15**: Section 4.1.5, Liner System Exposure Prevention	Section 4.1.5 of Appendix 7 in the design report does describe how the liner system (especially the geomembrane layers) will be protected from the wind. This can either be done by placing the soil/sand layers on the geomembrane quickly (e.g. same day) after it is installed, or by temporarily placing sand bags on it.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
21	**Comment 16**: Section 4.1.5, Liner System Exposure Prevention	Section 4.1.5 of Appendix 7 in the design report needs to discuss the problems associated exposing the GCL to moisture and describe how the GCL will be protected from hydrating before a uniform confining weight (e.g. 6 inches of soil) can be placed on it. Specifically, if the GCL is allowed to hydrate (e.g. swell) without any weight on it, it will lose its structural integrity and need to be replaced. To prevent this problem, the design report needs to indicate that two things will be done. First, each GCL panel (in the bottom, sides, and cover systems) needs to be covered with the geomembrane the same day the GCL is installed to protect it from precipitation and moisture in the air. Second, even after the GCL is protected from precipitation by the geomembrane, it will continue to hydrate by drawing moisture from the underlying soil in the subgrade. Therefore, at least 6 inches of soil/sand need to be placed on the GCL to provide uniform confining pressure on it before it is allowed to hydrate beyond 100%. The document needs to provide an estimate of how long it will take the GCL to hydrate to 100% (along with the justifications for this estimate), and show that the construction schedule will be sufficient to insure that adequate confining weight is placed on the GCL within this timeframe.	Specification 02245, Geosynthetic Clay Liner, Section 3.3, Installation, A.7, 8, 9 and 10 require the following: 7. Do not place GCL in the rain or at time of impending rain 8. Do not place GCL in areas of ponded water 9. Replace GCL that is hydrated before placement of overlying geomembrane 10. In general, only deploy GCL that can be covered during that day by geomembrane or a minimum of twelve (12) inches of approved cover soil. These requirements, already in the specifications, address the first issue raised in Comment 16. As for the second issue, the liner system will be built before 100% hydration of the GCL liner will occur. Technical information on GCL hydration time is included in Attachment 8 of the Response to Comments Document. This information demonstrates that the containment cell will be built before complete GCL hydration occurs.	Included technical information as Appendix I	
22	**Comment 17**: Section 3.0, Site Characterization	The proposed location of the containment cell needs to be shown relative to the borings on Figure 3-1.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
23	**Comment 18**: Section 3.0, Site Characterization	Geologic cross sections from the surface down to the confining layer (bedrock) need to be provided. The location and elevations of the proposed containment cell needs to be shown on these cross sections.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
24	**Comment 19**: Section 3.0, Site Characterization	Piezometer PZ-1, and the three GB borings, all end in the sand layer (either SM or SP). None of the borings continues to the top of a confining layer (*which may be bedrock at this site*). The design report needs to characterize the geology from the surface down to the first confining layer. This requirement can be met by either providing a the boring log report for an existing boring near the site that extends down to a confining layer, or by installing an additional boring at the site that extends a confining layer.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
25	<u>Comment 20</u>: Section 3 and Appendix A in Appendix 7, Laboratory Test Data	The following test results and information regarding the soils under the site need to be provided: a. Unconfined compression test results (shear strengths) for the upper clay layer, the loose sand layer, and the dense sand layer under the site. b. Consolidation test results for the upper clay layer, the loose sand layer, and the dense sand layer under the site. c. Hydraulic conductivity test results for all soil strata under the site (the upper clay layer, the silt layer, the loose sand layer, and the dense sand layer). d. The ASTM, EPA or other appropriate standard methods used to perform the tests needs to be identified in the document.	Unconfined compressive strength and consolidation tests will be performed on representative samples of the silty clay (CL) and sandy silt (ML) soils found in shallow soils at the containment cell site. In addition, the hydraulic conductivity of these soils will be determined by laboratory testing. ASTM, EPA or other appropriate test methods will be used to perform these tests and the test method will be included with the test results. These test results will be included in Appendix A, Site Characterization, of the Design Report. Unconfined compressive strength and consolidation tests can not be performed on sand samples. While it is possible to perform laboratory permeability tests on sand samples, the purpose of collecting this information is unclear. Therefore, these tests will not be performed.	Section 3 and Appendix A	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
26	**Comment 21**: Section 4.2.1, Settlement Potential	The assumptions used to calculate differential settlement are not acceptable. The settlement under the landfill needs to be recalculated considering the following comments: a. Density and Soil Strata: The calculations assume a single density for the soil and then assume it is equal to the density of the waste. There are four different soil strata under the site. The calculations need to account for the characteristics of each soil strata and each of the material that is in the liner system. In addition, the calculations need to account for the weight of the gravel or the liner materials. Finally, the actual density (and moisture content) of the sediments needs to be determined and used in the calculations. b. Base Elevations: The calculations assume an initial flat surface elevation. However, the narrative states the initial elevation of the site varies by 10 feet. The calculations need to account for the change in elevation across the landfill. This is especially true if the elevation change is because the surface layer (such as the clay) was removed from a portion of the site. c. Settlement of Berms: The settlement calculations consider the embankment and fill areas separately. However, the discussion and calculations on differential settlement need to clarify the way the	Settlement calculations are included in Attachment 9 of this Response to Comments Document and will be included in Appendix B, Foundation Evaluation, of the Design Report.	Appendix B: Foundation Evalatuion	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
		d. entire landfill is expected to settle during both its construction and later after it is covered. Placement of wastes and the cover system on the interior slopes of the berms could also result in some amount of settlement under the berms. Therefore, the settlement calculations for the embankments need to be provided for the conditions both before, and after, the liner and waste are placed in the landfill. Finally, the design report needs to discuss how settlement of the berm relative to settlement the waste and liner system will impact the stresses placed on the components in the liner system. f. Maximum Differential Settlement: The calculations assume an average fill height, that the maximum settlement will occur in the middle of the landfill, and that the settlement at the edge is 2/3 of the settlement in the middle. Differential settlement calculations need to consider the maximum elevation of the landfill, where the maximum settlement is anticipated, and compare this to the location where the least amount of settlement will occur. Figure 5-2 shows the maximum elevation (~ 427') occurs in the southwest quadrant, not the middle of the landfill. The settlement under the maximum elevation needs to be compared to the settlement calculated under the sump area in the northeast corner.			

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		e. This comparison should give not only the maximum differential settlement, but also identify if settlement will negatively impact the bottom slope or leachate collection system. f. Calculations: The calculations used to estimate the consolidation in the computer model need to be provided with justifications for all assumptions used in the model.			
27	**Comment 22**: Section 4.2.2, Bearing Capacity	Section 4.2.2 states that undrained shear strengths were determined for the surficial clays and silts. However, the test results provided in Appendix B show that clay only made up the top 1 inch (of a 6 inch sample) for one of the three unconfined compression tests. Therefore, this section needs to be revised to reflect that the undrained shear strength is only known for the silts under the site. Conversely, additional testing could be done on the surficial clay to determine its undrained shear strength (this is the preferred option).	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
28	**Comment 23**: Section 4.2.2, Bearing Capacity	Section 4.2.2 needs to provide justification for the statement that the limiting bearing capacity strata was found to be the surficial clays and silts. Part of this justification should include providing the test results from all of the soil strata under the proposed landfill site.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
29	**Comment 24**: Section 4.2.3, Containment Cell Slope Stability	The narrative in this section is not adequate to demonstrate the containment cell is designed with an adequate factor of safety against slope failure. The following issues need to be addressed: a. References to Appendix B: Justifications for the factors of safety discussed in Section 4.2.3 are not provided. If these values are based on the computerized slope stability analyses in Appendix B, the narrative needs to reference this information. b. Equations and Calculations: All equations and calculations used in the slope stability analyses need to be provided. If a computer program is used, the equations that the program is based upon, the assumptions used for each run, and a copy of the program all need to be provided. c. Soil Strata Assumptions: The soil borings in Appendix A show clay (CL), silt (ML) and loose sand (SM) are present from the ground surface down to approximately 10 feet. However, the total Unit Weight and Saturated Unit Weight were assumed to be the same for each soil type modeled in each computer run in Appendix B. The document needs to justify assigning the same values to different soil types (e.g. provide soil analyses or refer to test results provided elsewhere in the document).	Factor of safety calculations on the liner system components are included in Attachment 10 of the Response to Comments Document. These calculations will be included in Design Report Appendix C - Liner System Components. Shear box testing (undrained shear strength, ASTM Method D 5321-92) of the GCL/geomembrane interface and the geonet/geomembrane interface will be conducted as part of conformance testing. These tests will be performed 30 days after the Notice to Proceed is sent to the cell construction contractor. A new section, Liner System Shear Box Testing, will be added to the Construction Quality Assurance Manual. It is included in Attachment 11 of the Response to Comments Document. It will also be included in Appendix F, Construction Quality Assurance Manual for Installation of Geosynthetic Components, of the Design Report.	• Section 4.2.3 • Appendix C • Appendix F (Section 2.2.2)	

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		d. Friction Angles: The slope stability evaluation needs to calculate the required interface angle that satisfies the required factor of safety (FS) $\geq$ 1.5 (or as specified in the regulations). This needs to be done for the berms (both interior and exterior slopes), all interfaces in the liner system, and the cover system. When the liner materials are delivered to the site they need to be tested to verify the required friction angles are achieved. In the case of the soils in the liner and berms, once they are compacted, they too need to be tested to verify the required friction angles are achieved. e. Interface Friction Angle: This section assumes an interface friction angle of 11 degrees between the geonet drainage material and the HDPE liner. The data and justification for this assumption need to be provided. f. Worst Case Interface: The document needs to include an evaluation of the interface friction angle between all interfaces in the liner (bottom, side, and cover) systems. Part of this evaluation must be the identification, and justification, of the two materials determined to have the worst-case interface friction angle. When an interface involving a GCL is investigated, the evaluation must consider the GCL is hydrated to at least 100% and discuss bentonite migration in the GCL.			

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
		g. Laboratory Testing of Liner Materials: The interface friction angles between the various layers in the liner systems (bottom, side, and cover) should be determined in the lab using a shear box (ASTM D5321-92), a large scale direct shear box (ASTM D5321), or a ring shear device (ASTM draft method). If an alternate method is proposed, the document must provide justification for this method.			
30	**Comment 25**: Section 4.2.6, Potential for Excess Hydrostatic or Gas Pressure	The design report needs to include calculations demonstrate that the weight of the completed landfill will be greater than the hydrostatic uplift pressure.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
31	**Comment 26**: Section 7 Material Compatibility Studies	This section needs to indicate the approximate date the compatibility testing will be concluded and results provided to USEPA and IEPA.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
32	**Comment 27**: *Section 4.3.2, Synthetic* Liner Strength	Section 4.3.2 makes a number of statements regarding the strength of the liner that are not justified in the narrative. The narrative needs to provide specific numbers and refer to specific calculations (not just the Appendix) and technical data sheets on the materials in order to justify conclusions such as the following: • The synthetic linings in the containment cell will not be subject to significant tensile stresses. • The side slope linings will not be overstressed. • The longitudinal seams are not expected to be significantly loaded. • The strain in the bottom lining due to settlement is well within the elastic limit for the HDPE lining. • It appears the bottom linings will not be overstressed	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

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33	**Comment 28**: Appendix C, Calculations on Lining Tensile Strength	The calculations need to be revised as necessary to address the following comments and provide justifications for the assumptions: a. The overburden stress should be calculated using maximum thickness over slope in order to determine the worst-case scenario, not the average. b. The calculations need to discuss how the liner's anchor figures into the calculation. c. The document needs to provide calculations for all materials in the liner system, not just the HDPE geomembrane. d. The justification for the interface friction angle between HDPE & HDPE needs to refer to the 1999 edition of Designing with Geosynthetics. e. The document needs to calculate the interface friction angles that satisfy the required factor of safety, and then verify these values are not exceeded by testing in the lab (see above comments on slope stability analysis). f. The stresses due to settlement do not appear to be addressed in this calculation. As part of this discussion, the document needs to indicate whether the berms or just the gravel and waste are expected to settle (and how much) after the lining materials are installed.	Factor of safety calculations on the liner system components are included in Attachment 10 of the Response to Comments Document. These calculations will be included in Design Report Appendix C - Liner System Components. Shear box testing (undrained shear strength, ASTM Method D 5321-92) of the GCL/geomembrane interface and the geonet/geomembrane interface will be conducted as part of conformance testing. These tests will be performed 30 days after the Notice to Proceed is sent to the cell construction contractor. A new section, Liner System Shear Box Testing, will be added to the Construction Quality Assurance Manual. It is included in Attachment 11 of the Response to Comments Document. It will also be included in Appendix F, Construction Quality Assurance Manual for Installation of Geosynthetic Components, of the Design Report.	• Section 4.2.3 • Appendix C • Appendix F	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
34	**Comment 29**: Section 4.3.3, Synthetic Liner Bedding	Section 4.3.3 did not provide any type of demonstration that sufficient bedding will be provided both above and below the synthetic liners to prevent rupture of the synthetic liner during installation and operation (i.e., thickness and gradation).	A wide range of soils, including sand, can be used as bedding material for geosynthetics. Specification 02200 - Earthwork, included in Attachment 4 of this Response to Comments Document, will be used for the geosynthetic bedding layers in the liner system. It will also be included in Appendix E, Technical Specifications, of the Design Report. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.	Section 4.3.3	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
35	**Comment 30**: Appendix C, GCL Load Calculations	The calculations need to be revised as necessary to address the following comments and provide justifications for the assumptions: a. The overburden stress should be calculated using maximum thickness over slope in order to determine the worst-case scenario, not the average. b. The calculations need to discuss how the GCL's anchor figures into the calculation. c. A more detailed description (with calculations as necessary) needs to be provided to justify the statements that the entire downward force (T) must be carried by the internal shear strength of the GCL and that no tension is produced in the GCL. d. The document needs to describe how the overburden weight is transferred through the layers of the liner system above the GCL. Is the full tensile force (T) from the overburden weight transferred to the GCL, or was this a worst-case assumption? e. The calculations cite the CETCO Product Manual, Direct Shear Test Data as a source for an interface friction angle between the GCL and soil of 31°. A note on the cover of this data summary clearly states "This data is for informational purposes only and is not intended to	GCL load calculations are included in Attachment 12 of this Response to Comments Document and will be included in Appendix C, Liner System Component Design, of the Design Report. Liner system load calculations are in Attachment 6 of the Response to Comments Document. Factor of safety calculations are included in Attachment 10. Interface friction angles are discussed in the Response to Comment 28. Settlement calculations are given in Attachment 9.	• Appendix B • Appendix C	

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		replace project specific interface testing, which CETCO emphatically recommends." Therefore, this source for interface friction angles should not be used for design purposes. f. The document needs to calculate the interface friction angles that satisfy the required factor of safety, and then verify these values are met by testing in the lab (see above comments on slope stability analysis). g. The stresses due to settlement do not appear to be addressed in this calculation. As part of this discussion, the document needs to indicate whether the berms or just the gravel and waste are expected to settle (and how much) after the lining materials are installed.		•	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
36	**Comment 31**: Section 4.4.2, GCL Strength	Section 4.4.2 in Appendix 7 (page 4-10) states "all tensile stresses will be transferred through the GCL via the internal shear strength to the underlying soil layers." Appendix C also states that no tension is produced in the GCL. However, the Specification for GCLs (02245) in Appendix E states the minimum friction angle for hydrated GCL on a slope is 6°. This is less than the interface friction angles above (11°) and below (31°) the GCL. Therefore, the GCL will not be strong enough to transfer the tensile force to the soils underneath it. The conclusions in Section 4.4.2 and the calculations in Appendix C need to be reevaluated and/or additional documentation provided to demonstrate the GCL is strong enough to support the forces exerted on it.	Short term, long term and residual GCL strength calculations are included in Attachment 12 of this Response to Comments Document and will be included in Appendix C, Liner System Component Design, of the Design Report.	• Section 4.4.2 • Appendix C	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
37	**Comment 32**: Section 4.5, Leachate Collection System	The leachate collection system needs to be revised to include the following features: a. The proposal to monitor leachate on a monthly and then annual basis is not adequate to demonstrate that leachate will be removed from the landfill in a timely manner. The leachate collection system needs to include dedicated pumps, sensors, and plumbing to insure that the depth of leachate on top of the primary liner never exceeds one foot. The system pumps need to be automatically actuated by the liquid level in the sump. The system also needs to include a high level alarm to inform Monsanto/Solutia when the liquid level is above the acceptable elevation. The description of the system needs to identify the type of alarm and where the signal will be sent (e.g. the security office at the W.G. Krummrich Plant). b. Monsanto/Solutia may want to install an actual sump for the leachate collection system instead of just a gravel layer at the bottom of the slope. A sump at a lower elevation than the primary liner system probably will be necessary in order to meet the requirement to maintaining no more than one foot of leachate on the primary liner, and to accommodate the technical requirements for the pumps.	Leachate-collection system design will be modified to include a high-level alarm set to ensure that leachate levels in the leachate collection system are one foot or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future. Leachate collection system design modifications and details are included in Attachment 13. Modifications include a high-level alarm, a collection sump and a horizontal perforated pipe in the sump. These drawings will be included in the Design Report as Figures 4-7 A, B, C, D, E, F, G and H.	• Section 4.5.1 • Added figures	Renumbered Figures 4-7 through 4-16 for clarity

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		c. The elevation view(s) of the collections sump need to show the elevations at which the pump will turn on, turn off, and when the high level alarm will be actuated. d. The collection sump should include horizontal perforated pipes to house and protect the suction hoses used to remove leachate. e. A description of why a perforated instead of solid pipe will extend from the sump to the surface of the landfill. A perforated pipe should not be used outside of the sump because it could become a conduit for waste sediments to get into the sump and clog it. f. Detailed scale drawings (both plan and elevation views) of the leachate collection system and the leachate collection sump need to be provided. g. A more detailed description of how liquids will actually be removed from the sump also needs to be provided.		•	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
38	**Comment 33**: Section 4.5, Leachate Detection System	The design report needs to address the following comments regarding the leachate detection system: a. The design report needs to describe how the detection system will function to detect any leakage through either liner in a timely manner. The proposal to monitor leachate on a monthly and then annual basis is not adequate to make this demonstration. To insure the leachate detection system will detect (and is able to remove) leachate in a timely manner, the system needs to include liquid sensors, level actuated pumps, etc. b. The detection sump should include horizontal perforated pipes to house and protect the suction hoses used to remove leachate. c. Detailed scale drawings (both plan and elevation views) of the leachate detection system sump need to be provided. d. A more detailed description of how liquids will actually be removed from the sump also needs to be provided. e. The design report should include some discussion of why the leachate collection, detection, and capillary break sumps are located in separate areas instead of a vertical line.	Section 4.5.4, Maximum Leachate Head, Paragraph 4 will be modified to read: The model results show the leachate and leak production rates fall substantially after the cover system is installed over the cell. The leachate and leak production rates are essentially zero after the cell water balance has reached equilibrium. Some leachate production will continue for several months after the cell is covered. Leachate-detection system design will be modified to include a high-level alarm set to ensure that leachate levels in the leachate detection system are one foot or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future. Leachate detection system design modifications and details are included in Attachment 13. Modifications include a high level alarm, a collection sump and a horizontal perforated pipe in the sump. These drawings will be included in the Design Report as Figures 4-7 A, B, C, D, E, F, G and H. Leachate collection, leachate detection and capillary break sumps are located in a vertical line as shown in the Attachment 13 drawings.	• Added paragraph to Section 4.5.4 • Modified Section 4.5.1 • Added figures	Renumbered figures 4-7 through 4-16 for clarity

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
39	**Comment 34**: Section 4.5, Capillary Break Layer	The design report needs to address the following comments regarding the capillary break layer: a. Detailed scale drawings (both plan and elevation views) of the capillary break sump need to be provided. b. A more detailed description of how liquids will actually be removed from the sump also needs to be provided. c. The capillary break sump should include horizontal perforated pipes to house and protect the suction hoses used to remove leachate. d. At a minimum, the capillary break layer needs to include sensors and an alarm to inform Monsanto/Solutia when the liquid level in this layer is above a specified elevation. The narrative needs to identify this elevation, and include justification for it. The description of the system needs to identify the types of sensors and alarm, and where the signal will be sent (e.g. the security office at the W.G. Krummrich Plant).	Capillary break layer design will be modified to include a high-level alarm set to ensure that leachate levels in the capillary break layer are one foot or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future. Capillary break layer design modifications and details are included in Attachment 13. Modifications include a high level alarm, a collection sump and a horizontal perforated pipe in the sump. These drawings will be included in the Design Report as Figures 4-7 A, B, C, D, E, F, G and H.	• Section 4.5.1 • Added figures	Renumbered figures 4-7 through 4-16 for clarity

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
40	Comment 35: Section 4.5.2, Equivalent Capacity	Section 4.5.2 only states that the geonet transmissivity will be greater than 12 inches of sand with a hydraulic conductivity of 1×10^{-2} cm/sec. It needs to refer to copies of manufacture's data sheets provided for the geonet, and calculations that demonstrate this statement is correct.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
41	Comment 36: Section 4.5.3, Grading and Drainage	This section needs to include additional detail regarding the grading and drainage for the proposed landfill. Specifically: a. The description of the leachate collection system needs to include a demonstration of why perforated pipes are not included as part of the lateral leachate collection system on the bottom of the landfill. The narrative needs to discuss how the collected leachate will be disposed. Indicate the appropriate permits which will need to be obtained. As a newly generated waste, Monsanto/Solutia will need to determine if it is a hazardous waste. If it is a hazardous waste, storage of it for greater than 90 days is subject to the RCRA storage requirements.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
42	**Comment 37**: Section 4.5.4. Maximum Leachate Head	This section needs to provide the following information to clarify the conclusions in the document: a. Cross sections that identify each of the layers in both HELP models. b. Justifications for the assumptions used in the HELP models. For example, when the amount of leachate the sediments will generate is estimated, the report should include lab data from the field and bench/pilot scale tests regarding the moisture content of the sediments and descriptions the physical processes that will be used to dewater them before they are placed in the landfill. c. A description of why Layer 6 (waste sediments) is not included in the HELP model for the closed landfill, and why the average head on top of Layer 8 (the primary liner) is indicated to be 0.000 for each year. Thus, it appears the model assumes that all liquids will be squeezed out of the sediments during construction of the landfill, and no precipitation gets through the cover system. The report needs to provide additional discussion and justification for this assumption.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
43	**Comment 38**: Section 4.5.7 Prevention of Clogging	The following information regarding geotextiles needs to be included in the report: a. A sieve analysis of the waste material needs to be performed on both the sediments and the soil used in the primary liner system. This data then needs to be compared to the technical data sheet for the GCL. This is necessary in order to demonstrate the weight and apparent size opening (AOS) of the geotextile(s) is adequate for the design and will not clog. b. Describe how clogging would be detected and what cleanup procedures would be used to restore the capacity of the systems.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
44	**Comment 39**: Testing of Liner Materials	Appendices E, F and G of Appendix 7 need to be revised include testing the liner materials in a shear box to verify the internal and interface friction angles for the materials are sufficient to meet the factor of safety required for the design.	Shear box testing (undrained shear strength, ASTM Method D 5321-92) of the GCL/geomembrane interface and the geonet/geomembrane interface will be conducted as part of conformance testing. These tests will be performed 30 days after the Notice to Proceed is sent to the cell construction contractor. A new section, Liner System Shear Box Testing, will be added to the Construction Quality Assurance Manual. It is included in Attachment 11 of the Response to Comments Document. It will also be included in Appendix F, Construction Quality Assurance Manual for Installation of Geosynthetic Components, of the Design Report.	• Section 4.2.3 • Specifications - 02244 - 02245 - 02246 • Appendix F	

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45	**Comment 40**: Specification 01010 Summary of Work; Section 1.3.B.2. Principal Work Items to be Performed by Contractor	This subsection does not include the placement of the soil layer directly below the primary geomembrane liner. It also will need to be revised to include installation of the geotextile this reviewer recommends be placed between the gravel capillary break layer and the GCL bedding layer.	Installation of a soil layer below the primary geomembrane liner and installation of a geotextile on top of the capillary break layer will be added to Specification 01010. The list of principal work items included in Section 1.3.B.2 will be modified as shown below: • Mobilization to site • Site preparation to include clear and grub, borrow area development, erosion control, haul road development and stormwater management measures • Perimeter berm construction • Construct capillary break ground layer and sump • Construct tracked in place soil layer • Install geotextile • Install geosynthetic clay liner • Secondary geomembrane installation • Secondary leachate collection system installation including sumps and riser pipes • Constructed tracked in place soil layer • Install primary geomembrane layer A specification for the geotextile placed between the capillary break layer and the GCL bedding layer will be developed and added to the Technical Specifications. It is included in Attachment 14 of this Response to Comments Document and will be added to Specification 02242 of the Design Report.	Specification 01010 (Section 1.3.B.2)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
46	**Comment 41**: Specification 02150, Stormwater Control During Construction; Section 3.2 Groundwater Control	Groundwater in the area of the proposed containment cell may be contaminated with hazardous constituents from other sites in the area such as Site G. Therefore, this subsection needs to specify that collected groundwater will be tested to determine if it contains hazardous constituents, and/or is a hazardous waste. In addition, because it is not acceptable to manage contaminated groundwater the same way as uncontaminated stormwater, Specification 02150 needs to include procedures for handling groundwater that is determined to be contaminated with hazardous constituents.	Specification 02150, Section 3.2.B will be modified as shown below to indicate that the contractor must test collected groundwater and dispose of it in a manner consistent with the relevant and appropriate regulations: B. Collected groundwater must be stored and tested by the Contractor to determine if it contains hazardous constituents and/or is a hazardous waste. After testing, the collected groundwater must be disposed in a manner consistent with relevant and appropriate regulations. This revision will be incorporated verbatim into Section 3.2.B, Groundwater Control, of Specification 02150.	Specification 02150 (Section 3.2.B)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
47	**Comment 42**: Specification 02200, Earthwork, Section 2.3 Fill Material, and Section 3.6, Placement	These specifications need to be revised to address the following comments: a. Specification 02200 needs to include separate specifications for the bedding layer that will be placed under the GCL. The same specifications need to be applied to the soil layers under GCLs in the bottom, sides and cover systems because the goal of providing an adequate base for the GCL, and the rest of the liner system, is the same in each case. [Note: Specification 02200 currently does not include/address the layer under the GCL in the cover system.] b. In the case of the Compacted Fill, the top 1+ foot on the inside of the berm needs to meet the specification for the GCL bedding layer since this is the soil that will be in contact with the GCL. For the layers under the GCL in bottom liner and the cover system, the entire depth of these layers needs to meet the specification for the GCL bedding layer identified below. c. It is not acceptable to simply specify the soil types for the subgrade layers under a GCL as proposed in Section 2.3. The gradation of the soil, density, and moisture content all need to be specified (possibly in Section 3.6) in order to insure the soil will provide an adequate bedding layer for the GCL.	A wide range of soils, including sand, can be used as bedding material for geosynthetics. Specification 02200 - Earthwork, included in Attachment 4 of this Response to Comments Document, will be used for the geosynthetic bedding layers in the liner system. It will also be included in Appendix E, Technical Specifications, of the Design Report. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.	Specification 02200 - Section 2.3.B.3 - Section 3.6.C.8	

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		d. As stated earlier in the comments on Section 4.1.1 regarding the subgrade under the GCL, the subgrade needs to be constructed of a soil that will provide a firm bedding layer that will be rolled smooth. In addition, this bedding layer must be able to retain these characteristics throughout the construction process. Therefore, it is recommended that the bedding layer under all GCLs be constructed of soil with: i. 100% of the particles having a maximum dimension not greater than 2 inches, ii. Not more than 10% of the particles, by weight, having a dimension greater than 0.75 inches, iii. Not less than 50% of the particles, by weight, passing through the 200 mesh sieve, and iv. Not less than 25% of the particles, by weight, having a maximum dimension not greater than 0.002 millimeters. The bedding layer under a GCL needs to be compacted to at least 95% of the Standard Proctor Density using ASTM D-689, have a moisture content at or near optimum, and be smooth rolled so that there are no sharp edges or protruding objects in the surface. All of these specifications need to be included in Specification 02200.			

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
48	**Comment 43**: Specification 02200, Earthwork, Section 2.3 Fill Material	The specifications for Protective Fill need to be revised to specify the protective fill in contact with the GCL shall not contain dirt clods greater than 2 inches.	A wide range of soils, including sand, can be used as bedding material for geosynthetics. Specification 02200 - Earthwork, included in Attachment 4 of this Response to Comments Document, will be used for the geosynthetic bedding layers in the liner system. It will also be included in Appendix E, Technical Specifications, of the Design Report. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.	Specification 02200 - Section 2.3.B.3 - Section 3.6.C.8 -	
49	**Comment 44**: Specification 02200, Earthwork, Section 2.3 Fill Material	The specifications for each soil layer in the bottom, side, and cover systems need to refer back to the cross section details that describe the relative locations of these layers (e.g. Figures 4-1, 4-2, and 5-2). In addition, the specifications (and the CQAP in Appendix G) need to indicate that the thicknesses shown in the figures are the **compacted** thicknesses of the layer.	Cross-referencing the Design Report, design drawings and the specifications creates the potential for conflicts among the various documents. This is turn creates problems for the Owner and the Contractor. Order of document precedence will be set out in the bid package and will be used to determine which document governs a particular situation. Cross referencing disrupt this order of precedence. A note will be added to Design Report Figures 4-1, 4-2, 4-7 A, B, C, D, E, F, G and H and 5-2, to indicate that thicknesses are compacted thicknesses. Revised figures are included in Attachment 15 of this Response to Comments Document.	Modified figures - added note	
50	**Comment 45**: Comments on Specification 02200, Earthwork, Section 2.4, Equipment	This section needs to include specifications for the equipment used to smooth roll the soil used for the GCL subgrade.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
51	<u>Comment 46</u>: Specification 02200, Earthwork, Section 3.6, Placement	This section needs to be revised to address the following comments: a. Section 3.6.A.4. states that "differences in elevation for materials placed and compacted shall not exceed four feet . . ." Since material should not be placed in lifts in excess of eight (8) inches, this 4 foot difference seems excessive. The basis for a four (4) foot difference needs to be provided, and the specification revised as necessary to clarify its intent. b. Section 3.6.B.9. states lift thickness shall be controlled by the contractor through the use of grade stacks. This by itself is not adequate. The maximum depth of a loose lift needs to be specified in the specification: In general, the maximum depth of a loose lift should not be greater than eight (8) inches. c. Section 3.6.C.8 states the density of the tracked in place soil shall be no less than 90% of the maximum Standard Proctor dry density. However, other parts of the document state this layer will not be compacted. The portions of the Design Report that discuss this soil layer need to be revised as necessary to insure the document is consistent.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
52	**Comment 47**: Specification 02200, Earthwork, Section 3.10, Quality Control	Item A.10 requires data to be sealed by a Florida registered P.E. The section needs to be revised to reference an Illinois registered P.E. In addition, URS/ Monsanto/Solutia need to review the entire document to insure references to Florida requirements are removed from the document.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
53	**Comment 48**: Specification 02225, Sediment Material Handling, Section 3.3, Placing and Spreading Sediments	This specification needs to state that sediments will not be placed in the cell from the top of the berms and/or pushed down the side slopes. This type of filling procedure should be avoided because it can damage the side slope liner system. Sediments (wastes) should only be placed on the bottom of the landfill and pushed toward the side slopes.	Excavated sediments will be transported to the cell by truck. Trucks will use a ramp constructed inside the cell to transport sediments to the bottom of the cell. After the sediment is dumped, a bulldozer or other suitable equipment will be then used to spread the material. Section 3.3, Placing and Spreading Sediments, of Specification 02225, Sediment Material Handling, will be amended to include the following statements: M. Contractor shall not place sediment in the cell from the top of the berms or by pushing sediment down the side slopes. N. Contractor will place sediments only on the bottom of the cell and push them toward the side slopes. These changes will be incorporated into the Design Report verbatim.	Specification 02225 (Section 3.3)	
54	**Comment 49**: Specification 02227, Geogrid Reinforcement, Section 2.3, Geogrid	The use of "Geogrids" is not identified in the Figures provided in the Design Report. Details of how and where they will be used on the access ramp and cover need to be provided with the Figures in the Design Report.	Drawings showing geogrid use are included in Attachment 16 of this Response to Comments Document. They will be included in the Design Report as Figures 4-9 and 4-10.	Added figures	Renumbered figures 6-1 and 6-2

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55	<u>Comment 50</u>: Specification 02244, Geomembrane	The Installation Panel Layout Drawing referenced in Specification 02244 that identifies the placement of the geomembrane panels needs to be provided as part of Design Report.	Panel layout drawings will be prepared by the Contractor and submitted to the Agency 30 days prior to the start of liner installation. This information will also be included in the record drawings for the cell. Preparation of these drawings by the Design Engineer is not appropriate because it removes the Contractor's obligation to install the liner according to the design and specifications. Specification 02244, Section 1.5, Submittals, will be modified as shown below and incorporated in the Design Report: F. Installation Panel Layout Drawing identifying placement patterns and seams, both fabricated (if applicable) and field seams, as well as any variance or additional details which deviate from the Drawings. Layout shall be drawn to scale and shall be adequate for use as the construction plan, and shall include information such as dimensions, panel numbering, and installation details. The Engineer shall review all Panel Layout Drawings prior to installation. **Panel Layout Drawings, as prepared by the Contractor and reviewed by the Engineer, shall be submitted to USEPA 30 days prior to liner installation.**	Specification 02244 (Section 1.5.F)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
56	**Comment 51**: Specification 02244, Geomembrane	Specification 02244 needs to be revised to indicate that the HDPE geomembrane will be tested to verify it meets the minimum values for all of the parameters using the test methods and at the frequencies specified in the GRI standard GM13 (Rev. 3, June 28, 2000). Table 1(a) from GM13 that specifies the properties, test methods, minimum values, and frequencies is included as an attachment to these comments. **Note**: The values listed in the tables of GM13 are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).	Specification 02244, modified to include the test methods and frequencies in GRI Standard GM13 (Rev. 3, June 28, 2000), is given in Attachment 17 of this Response to Comments Document. It will be incorporated in the Technical Specifications of the Design Report verbatim.	Specification 02244 (Section 2.2.I)	
57	**Comment 52**: Specification 02244, Geomembrane, Section 2.4, Field Seams	Section 2.4 needs to specify that seams will be welded by double tracked fusion welding machines whenever possible. Corners, butt seams and long repairs need to be fusion welded where possible. Extrusion or fusion welding should be used for all other repairs, detail work and patches.	Section 2.4.A, Field Seams, of Specification 02244 will be changed to read as follows and included in the Technical Specifications of the Design Report: A. Approved processes for seaming are extrusion welding and fusion double seam welding. **Fusion double seam welding will be the primary method for joining long, straight seams. Extrusion welding will be the primary seaming method in areas such as corners, sumps, pipe penetrations, tear repairs and cap strips where fusion double seam welding is not feasible.**	Specification 02244 (Section 2.4.A)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
58	**Comment 53**: Specification 02244, Geomembrane, Section 3.4, Deployment	Section 3.4 needs to specify that geomembrane panels will be deployed on the side slopes the same way the GCL is required to be deployed in Specification 02245, by rolling them down the slope in a controlled manner. Geomembrane panels should not be pulled up the slopes.	Section 3.4.E, Deployment, of Specification 02244 will be rewritten as shown below and included in the Design Report Technical Specifications: E. Panels shall be oriented perpendicular to the line of the slope crest (i.e., down and not across slope), **anchored securely and deployed down the slope in a controlled manner. Panels shall not be pulled up the slope.**	Specification 02244 (Section 3.4.E)	
59	**Comment 54**: Specification 02245, GCL, Section 1.4 Delivery, Storage & Handling	It is recommended that section 1.4 of Specification 002245 be revised to require rolls of GCL to be stored off the ground on pallets from the time of delivery until they are installed.	Section 1.4.B.1, Storage and Protection, of Specification 02245 will be revised as follows and included verbatim in the Technical Specifications of the Design Report: 1. The Contractor shall provide on-site storage area for GCL rolls from time of delivery until installation. **Rolls of GCL will be stored off the ground from time of delivery until they are installed.**	Specification 02245 (Section 1.4.B.1)	
60	**Comment 55**: Specification 02245, GCL, Section 2.1 Materials	If a "lock-stitched" GCL is the same as one that is "needle-punched," the wording of this specification should be revised to reference a "needle-punched" GCL. If it is different, a copy of the manufacture's product data sheet that describes the process of creating a lock-stitched GCL needs to be provided.	Geosynthetic manufacturers and products will be identified in the Design Report. Manufacturers technical data sheets will be included for all geosynthetic components including geomembrane, GCL, geotextile, geonet and geogrid. These cut sheets are included as Attachment 1 of this Response to Comments Document and will be included as Appendix H of the Design Report.	Added Appendix H to report	
61	**Comment 56**: Specification 02245, GCL, Section 2.1 Materials	Table 1 needs to be revised to add the QC properties, tests methods, and testing frequencies specified in ASTM D-5889; Standard Practice for Quality Control of Geosynthetic Clay Liners. The minimum value for each of these additional properties also needs to be provided in the table.	Table 1 of Specification 02245 was modified to include the QC properties, test methods and testing frequencies specified in ASTM D-5889. Minimum values of these additional properties were also added to this table. Table 1 is in Attachment 18 of this Response to Comments and will be included in Specification 02245 of the Design Report.	Specification 02245 (Table 1)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
62	**Comment 57**: Specification 02245, Section 2.1 Materials	The minimum internal friction angle for hydrated GCL on a slope is identified as 6°. This is less than the interface friction angles above and below the GCL. The specification for the minimum internal friction angle for the GCL should be revised (increased), or additional information provided to justify this proposed minimum value (see earlier comments on Section 4.4.2, GCL Strength).	Short term, long term and residual GCL strength calculations are included in Attachment 12 of this Response to Comments Document and will be included in Appendix C, Liner System Component Design, of the Design Report.	• Calculations added to Appendix C • Specification 02245 (Table 1)	
63	**Comment 58**: Specification 02245, GCL, Section 3.3 Installation	The specifications for overlaps of GCL panels need to state that the panels should be overlapped/ layered in such a way that any liquid will run from one panel to the top of the next, rather than underneath it.	Section 3.3.B.2, Overlaps, of Specification 02245 will be amended as shown below to indicate that the GCL layers need to be overlapped so that any liquid will run from one panel to the top of the next. Placing GCL so that liquid from one layer can run underneath a lower layer will be prohibited. 2. In general, no horizontal seams are allowed on side slopes. **Any horizontal seams on side slopes will be overlapped so that liquid will run from the top of the higher panel to the top of the lower panel. GCL shall not be placed so that liquid from a higher panel can run underneath a lower panel.**	Specification 02245 (Section 3.3.B.2)	
64	**Comment 59**: Specification 02245, GCL, Section 3.4 Anchor Trench	The Figures/details of the liner system show the ends of the liner system laid out horizontally in the berm, not in an anchor trench. The application needs to be revised to consistently identify how the liner system will be anchored. It is recommended that an anchor trench be used to hold the liner system in place.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
65	**Comment 60**: Specification 02245, GCL	This specification does not include a section on Quality Control.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
66	**Comment 61**: Specification 02246, Geonet, Section 2.1	The table of geonet properties needs to be revised to include transmissivity, the test method used to measure this parameter, and the minimum acceptable value. The frequencies for testing each property should also be added to the table.	Geonet transmissivity values, test method and minimum acceptable values were added to Specification 02246. Manufacturers specifications and testing methods were also added to this table. The revised table is included in Attachment 19 of this Response to Comments Document and will be included verbatim in the Technical Specifications of the Design Report. It is inappropriate to test this material in the field since it will perform as designed unless damaged. Visual inspection will be used to insure that damaged geonet is not installed. Specification 02246, Section 3.1, Geonet Placement and Handling, will be modified to prohibit the use of damaged geonet as shown below and included in the Technical Specifications: A. Handle all geonet is such a manner as to ensure it is not damaged in any way. **Damaged geonet shall not be installed. If geonet is damaged during or after installation, it shall be replaced.**	Specification 02246 (Section 3.1.A)	
67	**Comment 62**: Specification 02932, Seeding, Section 2.1 Seed Mixture	This section specifies the use of Pensacola Bahia seed and Bermuda grass seed on the cover of the landfill. It is questionable whether these types of grasses are acceptable for use in Illinois. The vegetation specifications for this site should required the seed mixture to conform to Illinois DOT Section 624.07 Seed Mixture Class 1 specifications, and include seeds such as Kentucky Bluegrass, Perennial Ryegrass, Red Top or Creeping Red Fescue, and Ladino or White Dutch Clover.	Specification 02932 was changed to include grass seed mixes appropriate for Illinois, specifically IDOT Section 250 Seed Mixture Class 1. The revised specification is included in Attachment 20 of this Response to Comments Document and will be included in the Technical Specifications section of the Design Report.	Specification 02932	
68	**Comment 63**: Gas Venting System	Appendix E and Appendix F do not appear to include any specifications for the materials used to vent gasses from the landfill, or the procedures to install these devices through the cover system.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
69	Comment 64: CQA Sampling	Because this landfill will be used to hold fairly high concentrations of PCBs, organic wastes, and heavy metals, it is very important that it is properly constructed. Therefore, in addition to the confirmation samples collected, analyzed and interpreted by the Construction Manager, the CQA consultant should be responsible for collecting and interpreting his or her own samples from the soils and liner materials used to construct the landfill.	The Construction Manager is not collecting, analyzing and interpreting confirmation samples. Implementation of the CQA Manual, which includes collection, analysis and interpretation of samples from the soils and liner materials used to construct the containment cell, is the responsibility of the CQA Consultant. To ensure that the containment cell is properly constructed, the CQA Consultant will implement the QCA Manual independent of the Construction Manager, Manufacturer and Installer. However, the CQA Consultant will report results to the Construction Manager, Designer and Owner. These reporting relationships are discussed in the response to Comment 65 below.		No action required

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
70	**Comment 65**: Quality Control or Quality Assurance	The Construction Quality Assurance Programs, and the Specifications to some extent, need to be revised to better define the rolls of the Construction Manager and CQA Consultant: a. An organizational chart that graphically describes how construction of the project will be organized needs to be provided. b. The CQA Manuals (Appendix E, Section 1.3.1.1 and Appendix G, Section 2.3.1.1) state that the Construction Manager is responsible for the organization and implementation of the quality assurance activities for the project. Thus it appears the Construction Manager is responsible for the CQA officer's duties. c. Several section within the specifications in Appendix E refer to quality assurance and/or quality evaluation. For example, Geonets, Specification 02246 includes sections titled Quality Assurance, Quality Control, and Material Quality Evaluation. As the Construction Manager is responsible for compliance with the requirements in the specification, it appears that the Construction Manager may also be performing Quality Assurance. The wording in the specifications needs to be revised where necessary to clearly state that the Construction Manager only performs Quality Control, not Quality Assurance.	The Construction Manager is responsible for ensuring that the containment cell is built properly. Paragraph 1, Section 1.3.1.1, Responsibilities of Appendix F, Construction Quality Assurance Manual for Installation of Geosynthetic Components for the Sauget Area 1 TSCA Landfill, states the following: The Construction Manager is responsible for all construction quality. The Construction Manager is responsible for the organization and implementation of the quality assurance activities for the project. Section 1.2.4, Geosynthetic Construction Quality Assurance Consultant, of the same document states: The Geosynthetic Construction Quality Assurance (CQA) Consultant is a firm independent from the Construction Manager, Manufacturer(s) and Installer that shall be responsible for observing and documenting activities related to the quality assurance of the production and installation of the geosynthetic system on behalf of Solutia. This clearly obviates the comment: "Thus, it appears the Construction Manager is responsible for the CQA officer's duties." Appendix E, Construction Quality Assurance Manual for Installation of Soil Components of the Lining and Final Cover Systems for the Sauget Area 1 TSCA Landfill include the same language. To clarify reporting relationships of the CQA Consultant, the project organization chart in Attachment 21 of this Response to Comments Document will be included in Appendix F and Appendix E of the Design Report.	Appendices F and G	Added organization chart

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71	**Comment 66**: CQA Manual, Geosynthetics, Appendix F	The CQA Manual for installation of geosynthetic components needs to be revised to reflect earlier comments that have been made regarding the specifications and the properties of the geosynthetic components in the liner systems.	The CQA manual will be revised to incorporate earlier comments on specifications and properties of the geosynthetic components in the liner systems. It will be included in the final version of the Design Report.	Appendices F and G	
72	**Comment 67**: CQA Manual, Geosynthetics, Appendix F	The CQA Manual for installation of geosynthetic components needs to be revised to include a section on GCLs.	Section 6.0, Geosynthetic Clay Liners, will be added to Appendix F, Construction Quality Assurance Manual for Installation of Geosynthetic Components for the Sauget Area 1 TSCA Landfill. This new section is included as Attachment 22 of this Response to Comments Document.	Appendix F	
73	**Comment 68**: CQA Manual, Geosynthetics, Appendix F	It is recommended that an individual table be created for each geosynthetic component that lists the properties, test name and test method number, test frequency and the acceptable minimum/maximum values for each property.	A table listing the properties, test name and test method, test frequency and acceptable values of each geosynthetic component will be added to Appendix F, Construction Quality Assurance Manual for Installation of Geosynthetic Components for the Sauget Area 1 TSCA Landfill. This table is included as Attachment 23 of this Response to Comments Document.	Appendix F	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
74	**Comment 69**: CQA for Subgrade under Geomembranes	Section 2.3 Subgrade Preparation needs to specify quantifiable values for the subgrade. At a minimum, these need to include density, moisture content, maximum depth/height of ruts in the subgrade, and the size of rocks or sharp objects allowed in the top 6 inches of the soil below the geomembrane that are identified in the Specifications.	Section 2.3.1.3, Surface Preparation, will be amended to read as follows: The surface to be lined has been rolled, compacted, or handworked so as to be free of irregularities, protrusions, loose soil and abrupt changes in grade. **Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.** This text will be incorporated verbatim in Section 2.3.1 of Appendix F, Construction Quality Assurance Manual for Installation of Geosynthetic Components for the Sauget Area 1 TSCA Landfill.	Appendix F (Section 2.3.1)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
75	**<u>Comment 70</u>**: CQA for Geomembranes Relative to GCLs	Section 2.4.4, Method of Deployment needs to be revised to reflect the following comments regarding the placement of geomembrane on a GCL: a. Section 2.4.4 needs to specify the method used to deploy the geomembrane will not damage the GCL under the geomembrane (e.g. the heavy equipment used to install the geomembrane will not drive on the GCL, and the geomembrane will be rolled down the side slopes rather than dragged up them). b. Deployment (and welding) of geomembrane panels needs to be tied to installation of the GCL panels under the geomembrane. Specifically, the geomembrane needs to be installed the same day that the GCL panels directly under it are installed. c. The geomembrane needs to be covered with 6 inches of material before the GCL under it has time to become fully hydrated. When possible, the weight of 6 inches of material should be placed on the GCL the same day the GCL panel is installed. The CQA manual should refer to the calculations (required by these comments) that provide an estimate of the time it will take the GCL to become fully hydrated once it is installed.	Specification 02245, Section 3.3, Installation, requires the following: A. GCL deployment: Handle GCL in a manner to ensure it is not damaged. At a minimum comply with the following: 1. On slopes, anchor the GCL securely and deploy it down the slope in a controlled manner. 10. In general, only deploy GCL that can be covered during that day by geomembrane or a minimum of 12 inches of approved soil cover. These requirements are already included in the specifications and there is no apparent need to include them in the CQA Manual. As for the last issue, the liner system will be built before 100% hydration of the GCL liner will occur. Technical information on GCL hydration time is included in Attachment 8 of this Response to Comments Document. This information demonstrates that the containment cell will be built before complete GCL hydration occurs.	Appendix I	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
76	<u>Comment 71</u>: Wrinkles in Geomembranes	Both Section 2.4.4, Method of Deployment, and Section 2.8.5, Large Wrinkles need to be revised to address the following comments on wrinkles in geomembranes: a. Section 2.4.4 needs to identify a specific, measurable the size of a wrinkle in the geomembrane that is considered unacceptable. Both the width and height need to be specified. Section 2.4.4 needs to state that if a wrinkle is taller than it is wide, or is higher than 3 inches above the subgrade, the geomembrane panel should be readjusted to smooth out the wrinkle before it is welded to the next panel. b. There should not be any wrinkles in the geomembrane that is placed on top of the GCL since they can result in uneven pressures on the GCL. This can damage the integrity of the GCL by causing bentonite migration and an increase in the permeability of the GCL. c. CQA at the site needs to be capable of insuring that installation process does not result in a wrinkle that is 12 inches high. Section 2.8.5 needs to be revised to reflect that a wrinkle taller than it is wide, or higher than 3 inches above the subgrade, will be repaired.	Section 2.8.5, Large Wrinkles, Paragraph 1, will be revised as indicated below and included in Appendix F When seaming of the geomembrane is completed, and prior to placing overlying materials, the Geosynthetic CQA Consultant shall indicate to the Construction Manager which wrinkles should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation process, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. **The geomembrane will be inspected for wrinkles every morning by the Geosynthetic CQA Consultant and the results of the inspection will be documented. On completion of geomembrane installation, it will be inspected for wrinkles by the Geosynthetic CAQ Consultant and the Agency and the results of this inspection will be video recorded with a date stamp. Unacceptably large wrinkles will be removed after this final inspection.** Wrinkles are considered large when the geomembrane can be folded over on itself. Seams produced while repairing wrinkles shall be tested as outlined above.	Appendix F (Section 2.8.5)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
77	**Comment 72**: Seaming Geomembranes	Section 2.5.2, Acceptable Seaming Methods: As noted in the comments on the Specifications for geomembranes, this section needs to specify that the CQA consultant is responsible for insuring the use of extrusion welds will be minimized.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
78	**Comment 73**: Conformance Testing for Geonets	Transmissivity should be included as a conformance test in Section 4.2.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
79	**Comment 74**: CQA Manual, Soil Components, Appendix G	The CQA Manual for installation of soil components needs to be revised to include earlier comments regarding the specifications and properties of the soil components in the liner systems. For example, Section 4.2.3 Soil Selection Criteria needs to include a subsection for the bedding layer under the GCL, and additional criteria such as specifications for the grain size distributions need to.be provided for the various types of fills.	The CQA manual will be revised to incorporate earlier comments on specifications and properties of the geosynthetic components in the liner systems. It will be included in the final version of the Design Report.	Appendix G	
80	**Comment 75**: CQA Manual, Soil Components, Appendix G	It is recommended that an individual table be created for each soil component that lists the properties, test name and test method number, test frequency and the acceptable minimum/ maximum values for each property.	A table listing the properties, test name and test method, test frequency and acceptable values of each soil component will be added to Appendix G, Construction Quality Assurance Manual for Installation of Soil Components of the Liner and Final Cover Systems for the Sauget Area 1 Landfill. This table is included as Attachment 24 of this Response to Comments Document.	Appendix G	
81	**Comment 76**: CQA Manual, Soil Components, Appendix G, Section 4.2.3	The Soil Selection Criteria for each soil component needs to include measurement of the thickness of each soil component.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
82	**Comment 77**: CQA Manual, Soil Components, Appendix G, Section 4.2.4	The design report needs to identify the sources of the borrow soils on a scale drawing. It also needs to describe how these areas have been used in the past (e.g. agricultural, industrial, residential, etc.).	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		
83	**Comment 78**: CQA Manual, Soil Components, Appendix G, Section 4.2.4	The section titled Earth Fill Material Management needs to identify the parameters, test methods and testing frequencies for which the borrow soils will be analyzed. The minimum number of parameters and test frequencies for evaluating borrow sources are provided in Tables 2-2 and 2-3 of the USEPA Technical Guidance Document titled Quality Assurance and Quality Control for Waste Management Facilities (EPA/600/R-93/182, September 1993). If there is evidence, or it is suspected, that the source area may be contaminated with hazardous constituents, it may be necessary to perform additional tests in order to determine if the soils contain contaminants.	Off-site borrow will be sampled and analyzed for TCL/TAL constituents at a rate of one sample every 5,000 cubic yards. This testing requirement will be incorporated in Section 4.2.4 of the CQA Manual by adding this sentence to the end of the first paragraph: As the material is excavated from an approved borrow facility, the CQA Consultant shall confirm that the soils meet the requirements of the Specifications. The CQA consultant will use his/her experience with visual/manual soil classification techniques to assess the segregation of soils. The CQA Consultant will note in his/her field records changes in odor, texture, apparent moisture, and the depths of which they occur. The CQA Consultant shall confirm that adequate processing, as described in the Specifications, is performed for removal of roots, rocks, rubbish or unsuitable materials, and achieve the specified soil clod size. **Off-site borrow will be sampled and analyzed for TCL/TAL constituents at a rate of one sample every 5,000 cubic yards. Results will be compared to TACO Tier I criteria for commercial/industrial area soils. Soil with concentrations higher than these levels will not be accepted for use in containment cell construction.**	Appendix G (Section 4.2.4)	
84	**Comment 79**: CQA Manual, Soil Components, Appendix G, Section 4.3.3	The design report needs to clarify which component in the landfill design it considers the Low Permeability Fill.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
85	Comment 80: CQA Manual, Soil Components, Appendix G, Section 4.3.4	The evaluation of layer bonding states that test pits may be used (emphasis added). This section needs to specify the minimum number of test pits per lift per acre that will be used to evaluate the bonding of two lifts.	Paragraph 1 of Section 4.3.4, Evaluation of Layer Bonding, will be rewritten as follows and included verbatim in Appendix G, Construction Quality Assurance Manual for Installation of Soil Components of the Liner and Final Cover Systems for the Sauget Area 1 Landfill: **Evaluation of layer bonding will be determined by collecting one Shelby tube sample for every 10,000 square feet of compacted bottom soil. Shelby tubes will only be pushed 8 inches in order to protect the underlying liner system. Samples holes will be filled with bentonite.** **The CQA Consultant shall confirm that layer bonding between compacted lifts is adequate and that discontinuities do not appear to exist. This will be accomplished by cutting the Shelby tube sample in half longitudinally and visually examining the sample.** The CQA Consultant shall notify the Construction Manager of any layer bonding deemed to be deficient and shall confirm that repairs are performed by the Earthwork Contractor.	Appendix G (Section 4.3.4)	Renumbered to Section 4.3.3
86	Comment 81: Test Fill / Construction Proofing Ramp	It is recommended that a test pad be used to evaluate the bonding between the lifts prior to construction of the containment cell. The procedures for constructing and evaluating a test pad are provided in Section 2.10 of the USEPA Technical Guidance Document titled Quality Assurance and Quality Control for Waste Management Facilities (EPA/600/R-93/182, September 1993). Note: This same procedure can also be used to evaluate the soils proposed for use as the bedding layer below the GCL component of the liner.	Shelby tube samples will be used to check bonding between soil layers. Samples will be collected and checked at a frequency of one every 10,000 square feet. With this approach, a test pad is not needed to assure bonding between soil layers.		No action required

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
87	**Comment 82**: Maintenance Procedures for Leachate Collection and Detection Systems	Maintenance of the leachate collection and detection systems needs to be considered when these systems are designed. Therefore, the Design Report needs to describe the anticipated maintenance activities that will be used to assure proper operation of the leachate collection/ detection systems throughout the landfill's expected life, and describe how the design of these systems incorporates these maintenance activities. In addition, Exhibit 2 of the UAO included this item as a requirement in the Design Report.	Leachate collection and leachate detection systems were designed to be low maintenance systems. No maintenance is required to ensure that drainage occurs because both systems drain by gravity to their respective collection sumps. Vacuum trucks will be used to remove accumulated liquids from both sumps so no pump maintenance is required. Riser pipes and perforated pipe sections in the collection sumps are large enough to allow pressure washing should fouling occur.		No action required
88	**Comment 83**: Liner Repairs During Operation	The Design Report needs to describe the methods that will be used to repair any damage to the liner, which occurs while the landfill is in operation during placement of the waste (e.g. a dozer ripping the liner). This description needs to address all layers in the liner system.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
89	**Comment 84**: Run-Off Control Systems, Section 5.5	The design of the landfill needs include a run-off control system that is capable of holding the stormwater from a 25 year 24 hour storm after the unit is closed. It is not acceptable discharge the run-off from the closed landfill directly to Dead Creek. A run-off control system for the closed landfill will prevents sediments from washing off of the landfill and into the restored Dead Creek. Also, if the cover system fails, and the run-off becomes contaminated, the run-off control system will prevent the contaminated run-off, sediments and wastes, from entering and contaminating the restored Dead Creek. The description of the run-off control system needs to include the following: a. Design and Performance: Describe the run-off collection and control system design. Provide calculations demonstrating that the system has sufficient capacity to collect and hold the total run-off volume. Provide a plan view showing the locations of the run-off control system components, along with sufficient drawing details and cross sections. Indicate the fate of the collected run-off. b. Calculation of Peak Flow: Identify the total run-off volume expected to result from at least a 24-hour, 25-year storm. Describe data sources and methods used to make the peak flow calculation. Provide copies of the calculations and data, including appropriate references.	During construction, storm water in the cell will be pumped from the cell and discharged to Dead Creek. After sediment transfer, storm water in the cell will be treated, as required, and discharged to the POTW. Once the cover is installed, sedimentation will be controlled using best management practices. After vegetation is established there is no need to control runoff from the cell. Storm water runoff will be routed to a drainage swale on the north side of the cell that discharges to Dead Creek. Design drawings for this swale, which is designed to handle a 25 year, 24 hour storm, are included in Attachment 25 of this Response to Comments Document. They will be included as Figures 5-1 and 5-6 of the Design Report.	Modified figures 5-1 through 5-8	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
		c. Management of Collection and Holding Units: Describe how collection and holding facilities associated with run-on and run-off control systems will be emptied or otherwise managed expeditiously after storms to maintain system design capacity. Describe the fate of liquids discharged from these systems. d. Construction: Provide detailed construction and material specifications for the run-off control systems. Include descriptions of the construction quality control program that will be utilized to assure that construction is in accordance with design requirements. e. Maintenance: Describe any maintenance activities required to assure continued proper operation of the run-off control systems throughout the active life of the unit.			

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
90	**Comment 85**: Peak Flow and Design of Drainage Control Structures	The calculations in Appendix D need to be revised to address the following comments regarding the stormwater calculations: a. The first page of the stormwater control calculations refer to a peak flow of 16 cfs, but then use 8 cfs to calculate depth of flow and velocity. The QTR-55 computer model in indicates the peak flow for a 25 year 24 hour storm is 11 cfs. Therefore, the design calculations should use at least 11 cfs for the flow. b. The design of the down chute uses a depth of flow of 0.38 inches when the depth of flow in the drainage swale upstream from the chute is indicated to be 0.58 inches. The calculations need to identify how the depth of flow in the down chute was determined. c. The calculations for sheet flow use the amount of rainfall from a 2 year 24 hour storm. This is not acceptable. The design needs to be based on the rainfall from a 25 year 24 hour storm.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
91	**Comment 86**: Section 5.4 Cover System Design	As noted in earlier comments regarding the Specifications and liner materials, the cover system design needs address the following comments: a. The common name, species and variety of the proposed cover crop needs to be provided. b. Descriptions of GCL and synthetic liner components including chemical properties, strength, thickness and manufacturer's specifications. c. It is not acceptable to use sand as a bedding layer under the GCL component in the cover system. See earlier comment on bedding layer requirements for a GCL in the bottom liner.	The last sentence of Section 5.4.1, General, will be modified to read: The grassing will be with **grass seed mixes appropriate for Illinois, specifically IDOT Section 250 Seed Mixture Class 1.** Geosynthetic manufacturers and products will be identified in the Design Report. Manufacturers technical data sheets will be included for all geosynthetic components including Geomembrane, GCL, geotextile, geonet and geogrid. These cut sheets are included as Attachment 1 of this Response to Comments Document and will be included as Appendix H of the Design Report. A wide range of soils, including sand, can be used as bedding material for geosynthetics. Specification 02200 - Earthwork, included in Attachment 4 of this Response to Comments Document, will be used for the geosynthetic bedding layers in the liner system. It will also be included in Appendix E, Technical Specifications, of the Design Report. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.	Section 5.4.1	
92	**Comment 87**: Post-Closure Requirements	If the Post-Closure Requirements will be addressed in the O & M Plan, the Design Report needs to state this. Otherwise, they need to be included in the Design Report since they were included in Exhibit 2 of the UAO.	Comment to be addressed in the December 29, 2000 Response to Comments Document (Part III)		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
PART II: IEPA DISCUSSION OF RESPONSE TO COMMENTS - GROUP II (JANUARY 15, 2001)					
93	**Comment 8**	The technical data sheets included for Appendix H do not include the height of the textured surface (asperity height) of the HDPE geomembrane as requested in Comment 8.	The required height of the textured surface of the HDPE will be included in the technical data sheets of Appendix H.	Asperity height requirements were added to Specification 02244, Section 2.2.I. The required asperity height is 10 mils	
94	**Comment 11**	At the October 10, 11, 2000 meeting M/S also agreed to place the more highly contaminated material (e.g. Segment B) more to the middle of the fill, not near the bottom or sides. The response does not address this issue.	Monsanto / Solutia agreed that to the extent practicable material would be placed into the cell to prevent damage to the liner system which may include placing certain materials within the center. Due to the nature of the double liner system preventing damage to the liner will provide the highest level of protection to the surrounding soils and groundwater.		No action required
95	**Comment 12**	A more legible geologic cross section with all of the information requested in Comment 12 needs to be provided. The colors used to differentiate the geologic strata need to be lighter and the water table should be identified graphically on the cross-section. The information presented in the figure includes a very large distance. Therefore, it is recommended that the geologic cross section and other information be presented on a full size drawing.	A more legible geologic cross section will be provided providing better differentiation of the strata and the location of the groundwater. This information will be presented using 11x17 paper.	Figure 3-5	
96	**Comment 20.a, b**	The response to comment 20 needs to indicate when M/S will incorporate the test data into Appendix A of the Design Report.	The requested information will be included in the final version of the design report. The final design report will be issued after EPA / IEPA and Monsanto/ Solutia reach agreement on the responses to the comments.	Appendix A	
97	**Comment 24.a**	The narrative in Section 4.2.3 needs to b revised in order to address Comment 24.a and make the section consistent the revised calculations in Appendix C.	The narrative in Section 4.2.3 will be revised to be consistent with the calculations and results in Appendix C of the Design Report.	Design Report (Section 4.2.3)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
98	Comment 24.d	The narrative in Section 4.2.3 and the calculations in Appendix C (Attachment 10 to the response to comments) both need to be revised in order to clearly identify the minimum factor of safety (FS) against slope failure that will be acceptable. The FS for slope stability at this site should not be less than 1.5. A lower FS will also result in a lower interface friction angle being used in the design.	The calculations for the minimum factor of safety will be revised to reflect the minimum acceptable value of Factor of Safety of 1.5. The narrative in Section 4.2.3 of the Design Report will also be revised to reflect this minimum Factor of Safety value.	Design Report (Section 4.2.3)	
99	Comment 24.f	The interface friction angle should be determined for more than the two interfaces proposed in the response to comments. This is necessary in order to insure that the worst-case friction angle is in fact determined and accounted for in the design. For example, it is recommended that the soil – GCL and soil – smooth geomembrane interfaces should also be evaluated in the shear box.	Monsanto/Solutia agrees to include the interface friction testing in a shear box of the additional two interface surfaces requested; soil – GCL and soil – smooth HDPE.	• Design Report (Section 4.2.3) • Geosynthetic CQA Manual • Specifications 02244 and 02245	
100	Comment 24.g	It is strongly recommended that testing of the liner materials be performed as soon as the manufacturers of these materials are chosen. This testing would be in addition to, not in place of, the CQA confirmation testing.	The Specifications will be modified to require the contractor to submit the results of the conformance testing early. The specifications will be modified to require the contractor to provide this interface friction data " within 30 days of contract award".	Specifications 02244 and 02245	
101	Comment 29	The wording in Section 4.3.3 needs to be revised to reflect the response to Comment 29 and the provisions in Specification 02200 that address Comment 29.	Section 4.2.3 of the Design Report will be modified to reflect the response to Comment 29 and the modifications made in Specification 02200 regarding bedding material for the synthetic liners.	Design Report (Section 4.2.3)	
102	Comment 31	The wording in Section 4.4.2 needs to be revised to reflect the key provisions and conclusions in the revised GCL load calculations in Appendix C (Attachment 12) that address the concerns in Comment 31.	Section 4.4.2 of the Design Report will be revised to reflect the revised GCL load calculations and the concerns in Comment 31.	Design Report (Section 4.4.2)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
103	**Comment 32 all**	The narrative in Section 4.5 needs to be revised to include the wording in the response to comments for Comments 32, 33 & 34. Specifically, the narrative needs to refer to the revised drawings and describe how the leachate collection, detection and gravel capillary sump systems will function. Of particular concern is how the procedures and the alarm system will function to insure the level of leachate does not accumulate above acceptable levels.	The narrative of Section 4.5 will be modified to include the wording in the response to Comments 32, 33, and 34. This change will include references to the revised drawings and a description of how the leachate collection, detection and capillary layers will function.	Design Report (Section 4.5.1)	
104	**Comment 39**	The proposed wording in Attachment 11 needs to be revised to reference the ASTM method that will be used to test the samples, and the "selected geosynthetics" for which interface friction angles will be determined.	The working of Attachment 11 will be modified to include the reference to ASTM D5321 for the testing of interface friction values for "selected geosynthetics".	Appendix F (Section 2.2.2)	
105	**Comment 40**	The proposed revision to Section 1.3.B.2 of Specification 01010 is not correct. It needs to indicate that the geotextile will be placed between the tracked in place soil and the capillary break layer (gravel).	This change will be made to Specification 01010.	Specification 01010 (Section 1.3.B.3)	
106	**Comment 46.a**	The wording in Section 3.6.A.4 of Specification 02200 needs to be revised to more clearly describe the filling operations.	The wording of this specification will be modified to more clearly indicate that the requirement limiting the differential elevation of 4 feet in the compacted fill applies to the containment berms and not to any individual lift of placed and compacted soil.	Specifification 022200 (Section 3.6.A.4)	
107	**Comment 51**	Specification 02244 needs to be revised to include: yield stress and yield elongation.	These requirements will be included in the specifications.	Specification 02244	
108	**Comment 55**	The response to Comment 55 does not address the comment that Section 2.1 of Specification 02245 refers to a "lock-stitched" GCL.	References to "locked-stitch" GCL material will be replaced with "needle-punched".	Specification 02245	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
109	**Comment 56**	The minimum values for all of the parameters in Table 1 in Specification 02245 need to be provided in the Table.	The requested values will be provided in the Table.	Specification 02245	
110	**Comment 57**	The GCL Loading calculations in Attachment 12, and probably the Liner System Stability Calculations in Attachment 10, need to be revised to include the internal friction angle for the GCL.	The GCL loading calculations will be modified to also include consideration of the internal fraction angle of the GCL material.	Appendix C	
111	**Comment 61**	The minimum value for transmissivity in Specification 02246 is not acceptable or consistent with other portions of the Design Report, and the units of measurement are not correct. The design report needs to demonstrate that the geonet will have a transmissivity equal to 12 inches of sand with a hydraulic conductivity of 1×10^{-2} cm/sec as stated in Section 4.5.2 (see Comment 35). This is the transmissivity value that should be required in Specification 02246. [An acceptable value for transmissivity is on the order of 1×10^{-4} m^2/sec.] In addition, the narrative in Section 4.1.1 may need to be revised since it states the hydraulic transmissivity of the geonet will be at least 3×10^{-1} cm^2/sec (3×10^{-5} m^2/sec).	The Specification for the geonet will be modified to correctly represent the minimum value of transmissivity required by the calculations. In addition Section 4.1.1 of the Design Report will modified as appropriate.	Design Report (Section 4.1.1)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
112	Comment 64/65	The narrative in the Design Report should be revised to include the response to Comment 64. For example, Section 3.3 in the revised geonet Specification 02246 still shows that the contractor is responsible for taking confirmation samples. From the response to Comment 64 it appears that the CQA Consultant should perform this job. If this interpretation is correct, Specification 02246 (and portions of other specifications) may also need to be revised.	The narrative in the Design report will be revised to reflect the requirements of the Specifications and the CQA Manuals.	Design Report (Section 3.3)	
113	Comment 66	The revised CQA manual for geosynthetic materials (Appendix F) should have been provided with the November 3, 2000 submittal. This revised CQA manual needs to be provided for review before the Design Report is finalized.	The revised CQA Manual for geosynthetic materials will be included in the final submittal of the Design Report.	Appendix F	
114	Comment 68	The Table in Attachment 23 needs to be revised to include the following properties, their test methods, and minimum values: Geomembrane: yield strength, yield elongation, and asperity height, GCL: grab tensile strength. The minimum values for some of the parameters on this table may also need to be revised based on earlier comments in this review (e.g. transmissivity for the geonet, and the minimum internal friction angle for the GCL).	These values will be included in the referenced Table. The minimum values for these materials will be modified as appropriate.	Appendix F (Table 1)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
115	**Comment 74**	The revised CQA manual for soil materials (Appendix G) should have been provided with the November 3, 2000 submittal. This revised CQA manual needs to be provided for review before the Design Report is finalized.	The revised CQA Manual for geosynthetic materials will be included in the final submittal of the Design Report.	Appendix G	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
116	**Comment 78**	The response to this comment only addresses the testing of borrow soils for TCL/TAL constituents. It does not address the requirement to analyze soils per the referenced USEPA guidance document. Therefore, the parameters and their frequencies are specified below. [See copies of Tables 2.3 and 2.10 from USEPA Technical Guidance Document titled Quality Assurance and Quality Control for Waste Management Facilities (EPA/600/R-93/182, September 1993).] The soils identified in Tables 1A and 1B in Attachment 24 should be analyzed for the following parameters at the specified frequencies: - Moisture Content: 1 test per 2,500 cu yd or each change in material. - Atterberg Limits: 1 test per 6,500 cu yd or each change in material. - Percentage Fines: 1 test per 6,500 cu yd or each change in material. - Percent Gravel: 1 test per 6,500 cu yd or each change in material. - Compaction Curve: 1 test per 6,500 cu yd or each change in material. - Hydraulic Conductivity: 1 test per 13,000 cu yd or each change in material. The soils identified in Tables 1C in Attachment 24 should be analyzed for the following parameters at the specified frequencies: Field Placed Moisture and Density (rapid tests): 5 tests per acre per lift.	Revisions to these tables will be made to reflect the intent of the USEPA guidance document. Final versions of the tables will included in the Design Report.	Appendix G (Table)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
		Water Content (ASTM D2216): one in every 10 rapid moisture content tests. Total Density (ASTM D1556, 1587, or 2167): one in every 20 rapid density tests.			
117	**Comment 82**	The narrative in the Design Report needs to be revised to include the response to Comment 82.	Solutia will address the O&M issues for this facility in the O&M Plan. As previously agreed this plan will be submitted 60 days after the completion of construction.		No action required
118	**Comment 84**	The response did not fully address the issues in Comment 84. Each of the items in Comment 84 needs to be addressed individually. In addition, the response needs to indicate if the concrete down shoot (and the calculations for it in Appendix D) need to be removed from the application.	The run off control system was revised to incorporate the comments of EPA /IEPA. The revised design will be included in the final Design Report.	Appendix D	Replaced with subsequent responses

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
PART III: IEPA DISCUSSION OF RESPONSE TO COMMENTS - GROUP III (JANUARY 22, 2001)					
119	**Comment 15**: Section 4.1.5, Liner System Exposure Prevention	Section 4.1.5 of Appendix 7 in the design report does [not] describe how the liner system (especially the geomembrane layers) will be protected from the wind. This can either be done by placing the soil/sand layers on the geomembrane quickly (e.g. same day) after it is installed, or by temporarily placing sand bags on it.	Section 4.1.5 of Appendix 7 in the Design report will be modified to address protection from potential wind damage. A new paragraph will be added to incorporate the option of placing temporary sandbags or placement of the next layer of geosynthetic material as indicated below: Modify first paragraph "Certain synthetic components in the proposed lining system can be injured by various environmental exposures. Two potentially damaging environmental exposures are sunlight and wind. Sunlight can degrade unprotected plastics and polymers. Wind can displace and damage placed materials due to uplift causing pinholes, wrinkles and weakened locations at folds. The HDPE membrane linings...... Add a new paragraph "Wind damage to the geosynthetic liner systems is another potentially significant problem resulting from exposure to the elements. Damage to geosynthetics is typically due to displacement after the material has been installed. Prevention of this potential damage will be managed by placement of the succeeding soil / sand layer on the base of the landfill and via the use of sandbags on the side slopes of the cell.	Design Report (Section 4.1.5)	
120	**Comment 17**: Section 3.0, Site Characterization	The proposed location of the containment cell needs to be shown relative to the borings on Figure 3-1.	Figure 3-1 has been modified to present the location of the containment cell relative to the borings performed for design as requested. This revised drawing is included as Attachment 1 to this Response to Comments.	Figure 3-1	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
121	**Comment 18**: Section 3.0, Site Characterization	Geologic cross sections from the surface down to the confining layer (bedrock) need to be provided. The location and elevations of the proposed containment cell needs to be shown on these cross sections.	Geologic cross-sections from the surface down to the confining layer (identified as Figure 3-5) is provided as Attachment 2 to this Response to Comments. The relative location and elevation of the containment cell is shown on the figure.	Figure 3-5	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
122	**Comment 19**: Section 3.0, Site Characterization	Piezometer PZ-1, and the three GB borings, all end in the sand layer (either SM or SP). None of the borings continues to the top of a confining layer (which may be bedrock at this site). The design report needs to characterize the geology from the surface down to the first confining layer. This requirement can be met by either providing a the boring log report for an existing boring near the site that extends down to a confining layer, or by installing an additional boring at the site that extends a confining layer.	Information on characterization of site geology from ground surface to the first confining layer was provided in the Time Critical Removal Action Plan for Dead Creek Sediment and Soil in Section 2.6. Section 3.0 of the Design Report will be modified to include this information as described below: **"Section 3.5 GEOLOGIC CHARACTERIZATION** The Mississippi River floodplain contains unconsolidated valley fill deposits composed of recent alluvium (Cahokia Alluvium), which overlies glacial material identified as the Henry Formation. The Cahokia Alluvium 9recent deposits) consists of unconsolidated, poorly sorted, fine-grained materials with some local sand and clay lenses. These recent alluvium deposits unconformably overlie the Henry Formation which is Wisconsinian glacial outwash in the form of valley-train deposits. The Henry Formation is about 100 feet thick. These valley-train materials are generally medium to coarse sand and gravel and increase in grain size with depth. Unconsolidated deposits are underlain by bedrock of Pennsylvanian and Mississippian limestone and dolomite with lesser amounts of sandstone and shale. Figure 3-4 presents a surface map of the bedrock surface within the East St. Louis area. The approximate location of the site is included in that figure. Figure 3-5 presents a cross section of the site from ground surface to bedrock. The relative location of the containment cell is included in that cross section." Figure 3-4 is included as Attachment 3 to this Response to Comments.	• Design Report (Section 3.5) • Figure 3-4	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
123	**Comment 22**: Section 4.2.2, Bearing Capacity	Section 4.2.2 states that undrained shear strengths were determined for the surficial clays and silts. However, the test results provided in Appendix B show that clay only made up the top 1 inch (of a 6 inch sample) for one of the three unconfined compression tests. Therefore, this section needs to be revised to reflect that the undrained shear strength is only known for the silts under the site. Conversely, additional testing could be done on the surficial clay to determine its undrained shear strength (this is the preferred option).	Solutia has completed an additional site investigation to delineate the surficial soils and characterize their material and engineering properties. This second investigation, which updates and replaces the previous site investigation, is included in Attachment 4 to this Response to Comments. The information collected by this second field and laboratory investigation will be included as Appendix A of the final design report. As shown in Attachment 4 the included report incorporates the data and results of the first site investigation performed in December 1999. Shear strength data was collected for the surficial clay and silt strata from the second investigation. As presented in the report (Table1- Summary of Data for Key Strata) material and engineering characteristic properties for these materials has been characterized.	Appendix A	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
124	**Comment 23**: Section 4.2.2, Bearing Capacity	Section 4.2.2 needs to provide justification for the statement that the limiting bearing capacity strata was found to be the surficial clays and silts. Part of this justification should include providing the test results from all of the soil strata under the proposed landfill site.	As indicated above Solutia elected to perform additional site investigations to further characterize the material and engineering properties of the surficial soils beneath the proposed landfill. This additional information is included as Attachment 4 to this Response to Comments and will be included in Appendix B of the final design report. Using the recently collected information the bearing capacity of the surficial clays and silts was recalculated. That updated calculation is included as Attachment 5 to this Response to Comments. Based on this information the text of Section 4.2.2 of the final design report will be modified to read as follows: **Section 4.2.2 Bearing Capacity** The surficial clay and silt samples collected at the site were found to have undrained shear strengths ranging from 250 to 440 pounds per square foot (psf). Those strengths indicate soils with soft to firm consistency. The underlying sandy soils were observed to be very loose to medium dense. The limiting bearing capacity strata was found to be the surficial clays and silts. Based on the minimum undrained shear strength above, the ultimate bearing capacity of the existing subgrade soils is about 1,300 psf. Details of this evaluation are presented in Appendix B."	Design Report (Section 4.2.2)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
125	**Comment 25**: Section 4.2.6, Potential for Excess Hydrostatic or Gas Pressure	The design report needs to include calculations [to] demonstrate that the weight of the completed landfill will be greater than the hydrostatic uplift pressure.	The requested calculations are included as Attachment 6 to this Response to Comments. In addition, this calculation will be added to Appendix B. Section 4.2.6 of the design report will be modified to read as follows: **"Section 4.2.6 Potential for Excess Hydrostatic or Gas Pressure** Excess hydrostatic or gas pressure is not expected to affect the containment cell. The highest groundwater elevation observed at the site was over 8 ft below the proposed secondary lining elevation. The maximum flood elevation for this area is reportedly elevation 406. After the lining system is complete, the static weight of the soil layers in the lining system exceeds the potential hydrostatic uplift pressure. No heaving of the lining system is anticipated. Calculations demonstrating this point are included in Appendix B. The potential for gas pressure within the containment cell is low due to the relatively low quantity of decomposable matter in the wastes compared to a sanitary waste landfill. A venting system will be incorporated into the cover system to vent excess gas or barometric pressure from within the containment cell."	Appendix B (Section 4.2.6)	
126	**Comment 26**: Section 7 Material Compatibility Studies	This section needs to indicate the approximate date the compatibility testing will be concluded and results provided to USEPA and IEPA.	The study commissioned by Solutia to evaluate compatibility of the materials proposed to construct the Sauget Area 1 containment cell is now complete. This investigation demonstrates that the proposed materials are suitable for the intended use. The results of this study are included as Attachment 7 to this Response to Comments. This information will be incorporated into the final design report as Appendix H.	Appendix H	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
127	**Comment 27**: Section 4.3.2, Synthetic Liner Strength	Section 4.3.2 makes a number of statements regarding the strength of the liner that are not justified in the narrative. The narrative needs to provide specific numbers and refer to specific calculations (not just the Appendix) and technical data sheets on the materials in order to justify conclusions such as the following: • The synthetic linings in the containment cell will not be subject to significant tensile stresses. • The side slope linings will not be overstressed. • The longitudinal seams are not expected to be significantly loaded. • The strain in the bottom lining due to settlement is well within the elastic limit for the HDPE lining. • It appears the bottom linings will not be overstressed.	Information on synthetic liner strength performance was submitted with the response to the Group II Comments. Detailed calculations were provided in Attachment 6 of the Response to Comments - Group II. These calculations will be included in Appendix C of the final design report. Calculations on the induced strain in the geomembrane due to settlement of the landfill after construction and waste material placement is included as Attachment 8 to this Response to Comments and will be included in the final design report. Section 4.3.2 of the final design report will be modified as shown below. **"Section 4.3.2 Synthetic Liner Strength** Two loading conditions are anticipated for the synthetic linings, soil loading on side slopes and settlement of the bottom liner system. Calculations were performed to evaluate these two conditions. The linings on the cell's side slopes will be insulated from downdrag from the overlying waste material by a geonet drainage composite. Calculations in Appendix C (Lining Tensile Stress) for the lining stress due to the weight of soil sliding down the side slope show that the lining stress stays below the HDPE yield stress. Once wastes are placed and compacted in the cell, little down slope soil movement will be possible. This further limits the probability of lining downdrag. The cell construction specifications will prohibit dumping soil down unprotected side slopes. Where placement traffic on the side slope is required, the slope will be protected by geogrid reinforcements and additional HDPE fly sheets. As presented in Appendix C the side slope lining stress will be less than the yield stress of the HDPE geomembrane liner material. Lateral seams in the lining panels will be prohibited on the side slopes. Settlement of the bottom lining was previously identified to be minor. The strain in the bottom lining due to settlement as presented in Appendix C is well within the elastic limit for the HDPE lining.	Design Report (Section 4.3.2)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			Settlement calculations in Appendix A and Appendix B of the final design report indicate that differential settlement of the base of the containment cell after construction and waste placement will be approximately 2 inches. This translates into an elongation in the HDPE of approximately 1.3 x 10^{-5} in/in. Assuming an HDPE modulus of 30,000 psi the stress increase in the bottom lining is expected to be about 30 psi for each 0.1 percent strain. These values are far less than the yield strain of 13 percent for the geomembrane. As demonstrated in Appendix C the bottom linings will not be overstressed. Synthetic lining seaming will be performed using either hot-wedge or extrusion welding. Either method will be required to provide a film-tearing bond (FTB) in the parent HDPE linings. The strength of these seams will be required to achieve at least 90 and 50 percent of the HDPE lining tensile strength in shear and peel, respectively. The seams will be destructively tested periodically as provided in the Construction Quality Assurance Plan. All seams will be tested for hydraulic integrity using vacuum, air-pressure, or electrical methods. Appendix C presents details of this analysis."		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
128	**Comment 35**: *Section 4.5.2, Equivalent* Capacity	Section 4.5.2 only states that the geonet *transmissivity will be greater than 12 inches of* sand with a hydraulic conductivity of 1 x 10^{-2} cm/sec. It needs to refer to copies of manufacture's data sheets provided for the geonet, and calculations that demonstrate this statement is correct.	Calculations demonstrating that the geonet transmissivity will be equivalent to or greater than 12 inches of sand are included as Attachment 9 to this Response to Comments and will be incorporated in the final design report. These calculations refer to manufacturer's data sheets for a geonet material. Section 4.5.2 of the final design report will be modified as follows: **"Section 4.5.2 Equivalent Capacity of Geonet Drainage Composite** The geonet drainage composite used for all side slope collection layers and the leak detection bottom layer will have transmissivity values that are equivalent to that of a 12 inch thick sand layer with a hydraulic conductivity of 1 x 10^{-2} cm/sec. As demonstrated in Appendix C the geonet transmissivity is almost 2 orders of magnitude greater than the transmissivity of a sand layer."	• Design Report ((Section 4.5.2) • Appendix C	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
129	**Comment 36**: Section 4.5.3, Grading and Drainage	This section needs to include additional detail regarding the grading and drainage for the proposed landfill. Specifically: a. The description of the leachate collection system needs to include a demonstration of why perforated pipes are not included as part of the lateral leachate collection system on the bottom of the landfill. b. The narrative needs to discuss how the collected leachate will be disposed. Indicate the appropriate permits which will need to be obtained. As a newly generated waste, Monsanto/Solutia will need to determine if it is a hazardous waste. If it is a hazardous waste, storage of it for greater than 90 days is subject to the RCRA storage requirements.	a. The leachate collection system is designed based on the permeability of the sand and gravel of the collection layer without relying on pipes. This was achieved by selecting a combination of bottom slope, material permeability and length of collection system drainage path. The relative size of the proposed containment cell makes this disposal unit well suited to the leachate collection designed. Calculations demonstrating this are included as Attachment 10 to this Response to Comments. The text of Section 4.5.3 of the final design report will be modified as shown below. b. A description of the methods proposed for collection and disposal of leachate will be provided in the final version of the design report. Applicable rules and regulations will be met in the management of these fluids. The text of Section 4.5.3 will be modified as shown below. **"Section 4.5.3 Grading and Drainage** The bottom lining for the leachate collection system will slope at 3 percent beneath the sand layer toward the gravel sump and the gravel perimeter drains. The gravel drains slope at 1 percent (minimum) to a collection sump at one corner of the cell bottom. The grading for the leak detection system generally mirrors the collection system above. As demonstrated in Appendix C, based on conservative assumptions of inflow rate, the amount of leachate head that will develop in the primary collection system is considerably less than 12 inches at the farthest point from the collection sump. This calculation demonstrates that the containment cell does not require piping to achieve the regulatory performance standard for leachate development.	Design Report (Section 4.5.3)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			The sumps will be drained through HDPE pipes placed in each sump. The collection pipe will be unperforated from ground surface down to the gravel collection sump and perforated within the gravel collection sump. The piping will match the side slope grade and bend to transition from the slope to the bottom grade. End caps will be placed over the pipe ends to prevent foreign material and gravel entry. The pipe perforations will be 1/4-inch diameter. The entire length of piping within the gravel sump will be perforated. The 3/8-inch diameter gravel will provide adequate filter action to prevent clogging of the pipe perforations. The HELP model results indicate that leachate production will be minimal after the cover system is in place. The transmissivity of the sand, gravel, and geonet layers are adequate to rapidly transmit the leachate to the collection sump. The leachate level in each sump will be measured by installed liquid level monitors. Any liquids found in the collection piping will be removed via sump trucks or submersible pumps and placed in drums or tanks for disposal. Collected liquids will be tested to identify the presence of hazardous constituents and disposed in accordance with applicable regulations."		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
130	**Comment 37**: Section 4.5.4, Maximum Leachate Head	35. This section needs to provide the following information to clarify the conclusions in the document: a. Cross sections that identify each of the layers in both HELP models. b. Justifications for the assumptions used in the HELP models. For example, when the amount of leachate the sediments will generate is estimated, the report should include lab data from the field and bench/pilot scale tests regarding the moisture content of the sediments and descriptions the physical processes that will be used to dewater them before they are placed in the landfill. c. A description of why Layer 6 (waste sediments) is not included in the HELP model for the closed landfill, and why the average head on top of Layer 8 (the primary liner) is indicated to be 0.000 for each year. Thus, it appears the model assumes that all liquids will be squeezed out of the sediments during construction of the landfill, and no precipitation gets through the cover system. The report needs to provide additional discussion and justification for this assumption.	a. Cross sections identifying each layer used in the HELP model are included as Attachment 11 in this Response to Comments. This figure will be included in Appendix C of the final design report. b. Default values from the HELP program were used for each material type evaluated in the analysis. These assumptions estimate the initial moisture content for the placed sediments to be 25 percent. Field data from investigations performed at the site indicate the average moisture content of the surficial silts and clay soils to range from 14 to 30 percent above the water table and 30 to 35 percent below the water table. Assuming normal handling during excavation from the creek, drying and preparation for placement into the containment cell, the default values used in the analysis are very reasonable. c. Layer 6 (waste sediments) is included in the HELP analysis for both the closed case and the construction case. The analysis indicates that practically 100 percent of the precipitation is managed by the cover system. The volume of rainfall that does not run off (for the closed landfill case) is either evaporated, transmitted via the cover drainage layer or is absorbed as soil moisture by the topsoil layer or the contained sediments. The text of Section 4.5.4 of the design report will be modified as shown below: **"Section 4.5.4 Maximum Leachate Head** The HELP model was used to predict the leachate production and head levels within the cell during construction and after closure. The model results are shown in Appendix C.	Design Report (Section 4.5.4)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			The model results show that elevated leachate head may occur within the leachate collection layer during construction. The cell will behave like an open catchment and stormwater will collect on the waste surface. The construction model case assumed no stormwater pumping off the waste surface after rainfall events. As required by the specifications stormwater will be pumped off the waste surface as soon as possible to resume waste placement. The assumption of no surface water runoff and no pumping is therefore highly conservative. The construction model assumed that the cell was half-filled with wastes. Default values for initial soil moisture and hydraulic conductivity were used in the analysis. The maximum head in the leachate collection layer was greater than the 12-inch maximum. Therefore, the leachate collection sump will require pump out after each rainfall event during construction. The construction model indicates the peak leachate generation rate is about 4,000 gallons per day or 2.8 gallons per minute. The model results show that the leachate leakage into the detection layer during construction is about ¾-inch per year, which produces about 20,000 gallons of leachate in the expected 6-month construction period or about 110 gallons per day. Therefore, the leak detection layer will require checking and possibly pump out every other day during the construction period. The analysis assumed that the head in the leachate collection layer was not drawn down regularly, therefore the leachate leakage rate is conservative. The model results show the leachate and leak production rates fall substantially after the cover system is installed over the cell. Leachate development and leak production		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			are essentially zero after the cell water balance has reached equilibrium. As demonstrated by the analysis water that is not managed by the cover system via evapotranspiration is absorbed by the sediments contained within the cell. Some leachate production will continue for several months after the cell is covered due to continued gravity drainage of the placed sediments, however this is expected to diminish with time. Installed liquid level controls will continuously monitor the leachate and leak collection sumps. Periodic inspections (weekly or monthly) will be conducted until the production rate has reduced. Annual checks will be conducted thereafter. "		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
131	**Comment 38**: Section 4.5.7 Prevention of Clogging	The following information regarding geotextiles needs to be included in the report: b. A sieve analysis of the waste material needs to be performed on both the sediments and the soil used in the primary liner system. This data then needs to be compared to the technical data sheet for the GCL. This is necessary in order to demonstrate the weight and apparent size opening (AOS) of the geotextile(s) is adequate for the design and will not clog. c. Describe how clogging would be detected and what cleanup procedures would be used to restore the capacity of the systems.	a. It is not clear how the apparent opening size (AOS) of the GCL fabric will be effected by the grain size of the sediments and soil placed into the cell. We assume this question is intended to refer to the geotextile materials used for the leachate collection system. b. Since runoff form the surrounding drainage basin will transport sediments to the creek it is reasonable to assume the surrounding soils will be representative of the sediments within the creek. Calculations of the potential for geotextile clogging were performed in the draft design report and were reported in Appendix C. These calculations assumed an 8-ounce geotextile was used to filter sediments that consisted of fine sands and silts. Recent data collected from the site indicated that this assumption for grain size (D_{85} = 0.7 mm) is reasonable but the potential exists that some finer sediments may be present within Dead Creek. Grain size analyses of surficial silts and clays collected from the site indicates the distribution of fines within Dead Creek may be expected to have 100 percent of the material smaller than the #200 sieve. This distribution indicated that approximately 25 percent of the sediments are likely to be clay size fraction or smaller. Calculations using the above grain size distribution were performed to evaluate the potential for clogging the geotextile fabric. This information is included as Attachment 12 to this Response to Comments. This calculation will also be included in Appendix C of the finals design report. The text of Section 4.5.7 of the final design report will be modified as indicated below. The management of clogging and description of cleanup procedures will be addressed in the O&M manual. As previously indicated, Solutia agreed to submit this document within 60 days of start of construction. **"Section 4.5.7 Prevention of Clogging** Clogging in the leachate collection and leak detection systems is unlikely to affect the performance of the systems. The systems will	Design Report (Section 4.5.7)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			receive their highest loads during the waste placement with the loading expected to fall to near zero after the cover placement as reported in the Maximum Leachate Head section. The relatively short performance period for the system reduces the effect of clogging on the long-term performance of the cell. A geotextile and 6-inch sand layer protect the underlying sand and gravel drainage layers in the leachate collection system from clogging due to the waste materials. A geotextile over the geonet drainage composite on the side slopes protects geonet from clogging with the waste materials. Clogging the geotextile on the side slope should not be a concern since the leachate will continue to flow down slope to the bottom collection layer without applying head to the lining system. Calculations indicate that the average opening size for the geotextile selected to separate the contained sediments and soils from the leachate collection system is appropriate for the expected grain size of the Dead Creek sediments. The hydraulic capacity of the leachate collection and leak detection systems is many times greater than the highest demand placed on the layers. Minor clogging is not expected, but the capacity of the systems should provide adequate liquid drainage. After the cell is covered, the flows are nearly zero and clogging will not significantly limit the systems' performance. An analysis of geotextile clogging is presented in Appendix C."		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
132	**Comment 45**: Comments on Specification 02200, Earthwork, Section 2.4, Equipment	This section needs to include specifications for the equipment used to smooth roll the soil used for the GCL subgrade.	Specification 02200 - Earthwork, Section 2.4, Equipment will be modified to require the Contractor use a steel, smooth drum roller to prepare the compacted soil surface of the landfill prior to installing GCL material in the cell. This section of the Specification will be modified as shown below. **"Section 2.4 EQUIPMENT** 1. All equipment and tools used in the performance of this work are subject to the approval of the Construction Manager before work is started. 2. Contractor shall provide compaction equipment appropriate for the material types to obtain the densities specified. At a minimum "footed" rollers are expected for compaction of fine-grained soils or cohesive fills. Smooth drum rollers or hand compaction methods may be appropriate for granular drainage material sands and gravels. 3. Contractor shall provide hand-operated compaction equipment in areas closer than 2 ft from pipes or other appurtenant structures to obtain the densities specified. 4. Contractor shall operate and maintain compaction equipment in accordance with the manufacturer's instructions and recommendations. If inadequate densities are obtained, provide larger and/or different type equipment at no cost to the Owner. 5. Contractor shall provide equipment for applying water of a type and quality adequate for the Work, free of leaks and equipped with a distributor bar or other approved device to ensure uniform application. 6. Contractor shall provide equipment for mixing and drying out material, such as blades, discs, or other approved equipment.	Specification 02200 (Section 2.4.9)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			7. Contractor shall sufficiently weigh the compaction equipment such that the feet fully penetrate the loose lift during initial compaction. 8. Contractors mixing and blending equipment shall fully penetrate loose lifts during mixing to achieve a uniform material. 9. Contractor shall provide steel drum rollers to prepare the surface of placed or compacted fill prior to placement of geosynthetic materials."		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
133	**Comment 46**: Specification 02200, Earthwork, Section 3.6, Placement	This section needs to be revised to address the following comments: a. Section 3.6.A.4. states that "differences in elevation for materials placed and compacted shall not exceed four feet . . ." Since material should not be placed in lifts in excess of eight (8) inches, this 4 foot difference seems excessive. The basis for a four (4) foot difference needs to be provided, and the specification revised as necessary to clarify its intent. b. Section 3.6.B.9. states lift thickness shall be controlled by the contractor through the use of grade stacks. This by itself is not adequate. The maximum depth of a loose lift needs to be specified in the specification: In general, the maximum depth of a loose lift should not be greater than eight (8) inches. c. Section 3.6.C.8 states the density of the tracked in place soil shall be no less than 90% of the maximum Standard Proctor dry density. However, other parts of the document state this layer will not be compacted. The portions of the Design Report that discuss this soil layer need to be revised as necessary to insure the document is consistent.	a. Our experience with linear earthfill structures (berms, dams, etc.) indicates that differences in fill levels greater than four feet will create a potential vertical face in the embankment. That vertical face can become a seepage migration pathway, a preferential failure surface location or a weakened zone of fill with a tendency to crack. This is true even if the material was placed and compacted in lifts. Section 02200 -Earthwork was revised to reflect that the portion of the specification cited above only applies to the fill placed for the embankment and not to any specific lift. The proposed change to the wording of Specification 0200 Section 3.6.A is given below. "4. Contractor shall place and compact all materials to prevent constructed discontinuities in the fill or segregated areas of the work. Differences in elevation for segments of Compacted Fill shall not exceed four (4) ft unless otherwise approved in writing by the Construction Manager. Individual lifts are required to be placed and compacted per Section 3.6.B of these Specifications." b. Maximum loose lift thickness is required by Specification 02200 – Earthwork. Section 3.6.B.5 identifies the requirement for 12-inch thick loose lift thickness during placement. This was included in the draft version of the design report. c. The design report and Specifications have been modified to consistently require 90 percent of the maximum Standard Proctor dry density for tracked-in-place fill. Section 4.1.1 Paragraph 6 of the final design report will be modified as shown. "A geonet synthetic drainage composite will be installed over the secondary lining system to serve as the leak detection layer. A nonwoven geotextile will be placed over the geonet to prevent soil intrusion into the leak detection layer. The hydraulic transmissivity of	Specification 02200 (Section 3.6)	

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			geonet is at least 3 x 10^{-1} centimeters squared per second (cm^2/sec). At least 12 inches of native soil will be tracked in place over the leak detection layer on the cell bottom and compacted to 90 percent of the maximum dry density indicated by the Standard Proctor test. The native soil layer will not be installed on the containment cell side slopes."		
134	**Comment 47**: Specification 02200, Earthwork, Section 3.10, Quality Control	Item A.10 requires data to be sealed by a Florida registered P.E. The section needs to be revised to reference an Illinois registered P.E. In addition, URS/Monsanto/ Solutia need to review the entire document to insure references to Florida requirements are removed from the document.	Specification 02200 Section 3.10.A.10 has been modified to require an Illinois registered P.E. seal all data. The revised section is presented below. "10. Contractor shall submit all preconstruction and construction quality control data with a cover letter signed and sealed by an Illinois registered professional engineer indicating the requirements of the Specifications have been achieved and the data as presented is representative of the material tested."	Specification 02200 (Section 3.10.A)	
135	**Comment 59**: Specification 02245, GCL, Section 3.4 Anchor Trench	The Figures/details of the liner system show the ends of the liner system laid out horizontally in the berm, not in an anchor trench. The application needs to be revised to consistently identify how the liner system will be anchored. It is recommended that an anchor trench be used to hold the liner system in place.	The system used to secure the liner systems at the crest of the slope is based on standard design principals for anchor systems. The shape of the anchor "trench" in this case was based on efficient construction methods and control of stormwater during construction. As presented in the design report the anchor system provides the required amount of resistance for pullout and prevention of movement both during installation of geosynthetic materials and during placement of sediments into the cell.	Appendix C	
136	**Comment 60**: Specification 02245, GCL	This specification does not include a section on Quality Control.	The revised Specification 02245 – Geosynthetic Clay Liners with requirements for Quality Control is included as Attachment 13 to this Response to Comments. This revision will be included in the final design report.	Specification 02245	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
137	Comment 63: Gas Venting System	Appendix E and Appendix F do not appear to include any specifications for the materials used to vent gasses from the landfill, or the procedures to install these devices through the cover system.	Specifications for the materials and requirements for construction of the gas vents in the landfill cover are presented on the drawings. Attachment 14 presents Figure 5-3 from the draft design report with the requested information. This same figure will be included in the final design report.	Figure 5-3	
138	Comment 72: Seaming Geomembranes	Section 2.5.2, Acceptable Seaming Methods: As noted in the comments on the Specifications for geomembranes, this section needs to specify that the CQA consultant is responsible for insuring the use of extrusion welds will be minimized.	The revised Construction Quality Assurance Manual for the Installation of Geosynthetic Components is included as Attachment 15. This CQA manual is consistent with the requirements of the Specifications for geomembrane seaming.	Appendix F	
139	Comment 73: Conformance Testing for Geonets	Transmissivity should be included as a conformance test in Section 4.2.	As presented in Attachment 15 transmissivity is now included as a required conformance test in Section 4.2 of the Geosynthetic CQA manual.	Appendix F	
140	Comment 76: CQA Manual, Soil Components, Appendix G, Section 4.2.3	The Soil Selection Criteria for each soil component needs to include measurement of the thickness of each soil component.	The selection criteria defined in the CQA manual for soil components is intended to facilitate selection of the appropriate soil to be used in construction of each component of the landfill. Material thickness is not part of that consideration. Material thickness is currently included in Specification 02200 - Earthwork, Section 3.0 under material placement requirements.		No action required
141	Comment 77: CQA Manual, Soil Components, Appendix G, Section 4.2.4	The design report needs to identify the sources of the borrow soils on a scale drawing. It also needs to describe how these areas have been used in the past (e.g. agricultural, industrial, residential, etc.).	Due to several reasons, selection of the borrow site for landfill construction is the responsibility of the Contractor. Once a potential borrow site is identified information on chemical and physical characteristics of the proposed soils will be collected. The location of the borrow site and the above mentioned test results will be included in our final documentation of the constructed facility.		No action required
142	Comment 79: CQA Manual, Soil Components, Appendix G, Section 4.3.3	The design report needs to clarify which component in the landfill design it considers the Low Permeability Fill.	Identification of Low Permeability Fill has been removed from the text of the design report.	Appendix G	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
143	**Comment 83**: Liner Repairs During Operation	The Design Report needs to describe the methods that will be used to repair any damage to the liner, which occurs while the landfill is in operation during placement of the waste (e.g. a dozer ripping the liner). This description needs to address all layers in the liner system.	Methods used to repair the geosynthetic materials during placement of sediments and soils into the cell will be the same techniques used to construct the cell. Section 6.3 has been added to the final design report to clarify this point as shown below. **"Section 6.3 Repairs during Construction** During placement of the sediments and soils into the containment cell observations will be performed to ensure no damage occurs to the geosynthetic materials. If one of the synthetic materials is damaged the contractor will be required by the Construction Manager and CQA Inspector to immediately repair the damage. The means and methods for effecting these repairs will be the same as the methods used for construction. This requirement will include implementing the CQC requirements of the Specification and the CQA plan."	Design Report (Section 6.3)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
144	**Comment 85**: Peak Flow and Design of Drainage Control Structures	The calculations in Appendix D need to be revised to address the following comments regarding the stormwater calculations: a. The first page of the stormwater control calculations refer to a peak flow of 16 cfs, but then use 8 cfs to calculate depth of flow and velocity. The QTR-55 computer model in indicates the peak flow for a 25 year 24 hour storm is 11 cfs. Therefore, the design calculations should use at least 11 cfs for the flow. b. The design of the down chute uses a depth of flow of 0.38 inches when the depth of flow in the drainage swale upstream from the chute is indicated to be 0.58 inches. The calculations need to identify how the depth of flow in the down chute was determined. c. The calculations for sheet flow use the amount of rainfall from a 2 year 24 hour storm. This is not acceptable. The design needs to be based on the rainfall from a 25 year 24 hour storm.	The stormwater control system and the drainage control structures were modified to address these comments. The design calculations detailing these changes are included as Attachment 16.	• Design Report (Section 5.0) • Appendix D	Information modified by subsequent responses to comments

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
145	Comment 87: Post-Closure Requirements	If the Post-Closure Requirements will be addressed in the O & M Plan, the Design Report needs to state this. Otherwise, they need to be included in the Design Report since they were included in Exhibit 2 of the UAO.	The final Design Report will identify that these issues will be addressed in the O&M plan. Section 6.4 will be added to the final design report to present this information. Section 6.4 will read as follows. **"Section 6.4 Operation and Maintenance Requirements** Post closure requirements for the landfill will be identified in the operation and Maintenance Plan to be submitted by Solutia within 60 days of the start of construction."	Section 6.4	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
PART III: IEPA DISCUSSION OF RESPONSE TO COMMENTS - GROUP III (FEBRUARY 2001)					
146	**General**	The responses to all comments (e.g. 25, 27, 35, 36, and 85) do not indicate where the information provided with the response will be included in the final Design Report.	Detailed instructions on the proposed location of the changes to the design report were included in the response comments. As indicated in each response, the proposed change will either be incorporated in the an appendix to the report or included within the text of the document.		No action required
147	**Comments 18, 19**	Figure 3-5 was not provided.	This figure will be provided in the final design report.	Figure 3-5	
148	**Comment 36**	The response did not demonstrate why hard pipes are not necessary for the leachate collection system. The response states that the calculations in Attachment 10 demonstrate the design of the leachate collection system (drainage layers without hard piping) are well suited for the given design. The calculations show the maximum leachate head (without a cover system) could be as much as 17 feet. Thus, it is not clear how this calculation provides the required demonstration.	Landfill liner system performance is based on the permeability of the primary Leachate Collection and Removal System (LCRS). Increasing the permeability of this system will reduce the predicted head during the active and inactive phases of the landfill. The original landfill liner system design incorporated the use of sand as the drainage medium of the Primary LCRS layer. A HELP model analysis of this design (submitted with the Draft Work Plan) estimated a maximum hydraulic head of 16-inches over the primary liner system during the operating phase of the landfill. As demonstrated by our previous analyses, additional controls in the Primary LCRS appear warranted. To reduce potential leachate head on the primary system, a geonet layer will be incorporated in the Primary LCRS for leachate collection and conveyance. The proposed landfill liner system will now consist of the following layers (top to bottom):	• Design Report (Section 4.5.1) • Appendix C	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			• 12-inch thick sand layer with a hydraulic conductivity of 1×10^{-3} cm/sec • Non-woven geotextile fabric • Geonet drainage layer with 5 cm/sec permeability (new layer) • 60-mil HDPE • 12-inch tracked in place soil • Non-woven geotextile • Geonet drainage layer with 5 cm/sec permeability • 60-mil HDPE • Geosynthetic clay liner (GCL) • 6-inch tracked in place soil • Nonwoven geotextile • 36-inch thick gravel layer • Compacted subgrade The HELP model was executed using the above liner system configuration overlain by an 80-inch thick sediment layer. This modeling scenario in effect models the landfill during the filling activity and represents a worst case scenario. In addition, the following conservative assumptions were made and implemented in the HELP model run: • 100 percent of the rainfall will infiltrate into the placed fill • The filled sediments is exposed to the weather with no temporary or permanent cover • The permeability of the geonet is assumed to be 5 cm/sec. The following table summarizes the HELP model peak daily output for the head condition on the primary liner (layer 4):		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
			peak daily values for years 1974 through 1978		
			(inches) (cu ft) precipitation 3.80 13794.0 runoff 0.0 0.0 drainage from lateral drainage layer (Geonet, layer 3) 0.26 939.4 percolation/leakage through primary HDPE liner (layer 4) 0.0 .00005 average head on top of layer 4 0.126 maximum head on top of layer 4 0.247		
			Based on the HELP model results, the addition of a geonet layer will greatly reduce the hydraulic head on the liner system and mitigate the need to install piping on the bottom of the cell. Attachment 1 to this submittal includes the results of this HELP analysis. We recommend replacing the calculations provided as Attachment 10 of Solutia's response dated January 22, 2001 with the attached HELP model analysis of the revised liner system design (Attachment 1).		

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
149	**Comment 37.c**	The response did not adequately address the questions regarding the leachate levels in the HELP model. It is still not clear how/if the waste sediments (layer 6) is included in the HELP model of the closed landfill. Specifically, the annual totals for year 1 do not include this layer. Second, it is still not clear why the head on the HDPE (layer 8) goes to 0.0 feet in the first year. Given the leachate head that could accumulate in the landfill during construction, (see response to Comment 36 and Attachment 10), it seems unlikely that all this water would be gone in 1 year.	The HELP analysis of the closed landfill did include the waste sediment layer in the evaluation of potential leachate generation for both the operating and closed conditions. Initial moisture contents assumed in the analysis were default values assigned by the program. As indicated by our response to Comment 37.c in Solutia's January 22, 2001 submittal practically 100 percent of stormwater falling on the closed landfill is managed by the cover system. Stormwater that does infiltrate the cover system is absorbed by either the topsoil layer or the contained sediments.	Appendix C	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
150	Comment 38.b	The issue of clogging and cleanup of the leachate collection system needs to be addressed before the system is installed. (This is similar to the response given to Comment 82.) The response states that management of clogging and cleanup procedures will be provided in the O&M manual. This is not acceptable. First, the response did not address the question of how clogging would be detected. Second, these procedures need to be part of the Design Report since the leachate collection system cannot be modified once the landfill is completed. While it is true that the models show very little leachate is expected once the landfill is closed, clogging and cleanup of the leachate collection system are still important issues now because a problem with the cover system could result in an increase in leachate in the future.	In our opinion, the use of pipes as the primary leachate collection system will not improve the efficiency of the leachate collection and removal. Based on our experience we do not believe that installation of a piping system for leachate collection is appropriate for the following reasons: • Potential clogging of pipe perforations. • Carrying capacity of the pipes is much less that the drain system currently designed for the landfill. • If a section of the pipe does become clogged, that portion of the collection system is rendered useless until detected and cleaned. The sand and gravel layer proposed for the Primary LCRS (in addition to the geonet layer proposed for this system) is designed with a high degree of tolerance for clogging. If an area of the primary system was to experience some encrustation or localized clogging, leachate will not be prevented from entering the LCRS geonet layer or the gravel sump for removal from the system. Leachate will not accumulate over the system, the liquid will continue to seek the lowest possible level by flowing around the zone of reduced permeability.		No action required
151	Comment 85	The response does not adequately address the concerns regarding the design of the run-off control system.			

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
		a. The Design Report does not describe how the water will be managed when it reaches the bottom of the berm.	Perimeter ditching and a controlled downlet structure for stormwater falling on the landfill are incorporated into the design. To better manage the stormwater runoff and minimize the potential for erosion, the stormwater conveyance at the confluence of the two swales located at the northwest corner of the landfill (at the top of the berm) has been modified. The modification entails the installation of two interconnected drop inlets placed at different elevations. The first pre-cast inlet will be placed at the confluence of the two swales and the second inlet will be placed immediately to the north and will be set at a lower elevation. The stormwater will then flow out of the lower inlet into a drainage ditch with an ultimate outfall to Dead Creek, located on east of the landfill. In addition, the drainage ditch bottom slope was flattened and rip-rap will be added, as appropriate, to provide further erosion protection.	• Design Report (Section 5.0) • Appendix D	
		b. Illinois EPA is concerned with the design of the entrance to the downchute. This part of the design will redirect approximately half of the run-off 180°. A change in the flow direction to this extent will likely result in increased erosion to the drainage swales/berms. The report needs to discuss this design aspect of the system, how it will be designed to resist erosion, and why this design was chosen over other options such as having two down chutes.	The design of the downchute structure was modified to address IEPA's concerns regarding erosion and potential long term increased maintenance. To better manage the stormwater runoff and minimize the potential for erosion, the stormwater conveyance at the confluence of the two swales located at the northwest corner of the landfill (at the top of the berm) has been modified. The modification entails the installation of two interconnected drop inlets placed at different elevations. The first pre-cast inlet will be placed at the confluence of the two swales and the second inlet will be placed immediately to the north and will be set at a lower elevation. The stormwater will then flow out of the lower inlet into a drainage ditch with an ultimate outfall to Dead Creek, located on east of the landfill. In addition, the drainage ditch bottom slope was flattened and rip-rap will be added, as appropriate, to provide further erosion protection. The rational method was used to determine the total runoff from the cover system and to size the inlet system. The calculations and the design of the inlet drainage structures are based on a 25-year, 24-hour storm event. A copy of the design calculations is provided as Attachment 2 to this submittal.	• Design Report (Section 5.0) • Appendix D	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
		c. The response does not indicate why a 2-yr. storm event is used to calculate Time of Concentration.	The original calculations for the stormwater system were performed using the TR-55 model. To estimate the time of concentration for sheet flow, the model uses the following Manning's kinematic equation to compute T_c, $T_c = \frac{0.007\ (nL)^{0.8}}{(P_2)^{0.5}\ S^{0.4}}$ Where: T_c = Travel time (hr) n = Manning's roughness coefficient L = Flow length (ft) P_2 = 2-year, 24-hour rainfall (in), S = Slope of hydraulic gradient line (land slope, ft/ft) The 2-year, 24 hour storm event is recommended for sheet flow distances that are less than 300 feet by TR-55.	• Design Report (Section 5.0) • Appendix D	
		d. The calculations of the downchute on page 3 of 7 do not include the depth of flow or indicate if a velocity of 8.9 fps is acceptable.	The design of the downchute structure was modified to address IEPA's concerns regarding erosion and potential long term increased maintenance. To better manage the stormwater runoff and minimize the potential for erosion, the stormwater conveyance at the confluence of the two swales located at the northwest corner of the landfill (at the top of the berm) has been modified. The modification entails the installation of two interconnected drop inlets placed at different elevations. The first pre-cast inlet will be placed at the confluence of the two swales and the second inlet will be placed immediately to the north and will be set at a lower elevation. The stormwater will then flow out of the lower inlet into a drainage ditch with an ultimate outfall to Dead Creek, located on east of the landfill. In addition, the drainage ditch bottom slope was flattened and rip-rap will be added, as appropriate, to provide further erosion protection.	• Appendix D (Figure 5-1)	

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
PART III: IEPA ADDITIONAL DISCUSSION OF RESPONSE TO COMMENTS - GROUP III (MARCH 2, 2001)					
152	**Comment 1**	Regarding Response No. 85 (surface water runoff) in the February 27, 2001 submittal, please provide a drawing of the proposed storm water management system.	Two drawings are provided with this submittal as Attachment 1. These drawings reflect the proposed changes to the landfill cover storm water management system.	Figure 5-1	
153	**Comment 2**	Clarification question to Response 36 regarding the HELP model analysis			
		(a) The format is different from the last one - why?	The format for the HELP analysis submitted on February 27, 2001 is essentially the same as that submitted with the Draft Design Report. The HELP model runs provided in our February 27, 2001 submittal were based on a 1-acre size cell. The HELP analysis provided in the Draft Design Report was based on 2.910 acres. The drainage distance to the sump in the February 27, 2001 analysis was the same as that used in the Draft Design Report. This should have no impact on the prediction of head on the primary liner system. However, the leachate generation rate is sensitive to the total area of the cell evaluated. To estimate the leachate generation rate for the entire landfill area, the generation rate/acre can be multiplied by the total acres to determine the overall volume. Therefore, assuming a 3-acre cell, the maximum leachate generation rate expected to develop from the Primary LCRS (Layer 3) will be less than 0.8 in.		No action required

Item Number	Comment Number	IEPA Comment or Discussion of Response	Solutia Response	Design Report Section(s) Modified	Comments
		(b) The period for the HELP analysis submitted on February 27, 2001 appears to be 1974 to 1978. Why is the period used different from the last one - which was for a different and longer period (20 years). Mr. Watson did comment that a four-year period is probably appropriate since the model is only for construction of the landfill.	The weather data for a 5-year period (1974-1978, inclusive) was used instead of the 20-year period provided in the HELP analysis in the Draft Design Report. The HELP model contains default weather data for various parts of the United States. The five-year data used in the February 27, 2001 submittal is based on actual measurement of climatic conditions for the five year period of 1974 through 1978. The HELP model run included in the Draft Design Report used actual data for a 20-year period. The default rainfall data provided in the program is a more conservative estimate. For instance, the daily peak rainfall for the 5-year period (1974 through 1978) is 3.80 inches compared to 3.44 inches for the 20-year data. Therefore, the HELP analysis provided in the February 27, 2001 evaluation is a conservative estimate of system performance.	Appendix C	
		(c) The HELP model should be labeled or titled "FOR CONSTRUCTION ONLY"	The HELP model will be labeled "For Construction only."	Appendix C	

Solutia Inc. has entered into a Unilateral Action Order (UAO) agreement with Region V of the U.S. Environmental Protection Agency (EP) to address concerns regarding affected sediments and soils in and adjacent to Dead Creek in Cahokia, Illinois. The sediments within Dead Creek are part of a larger Superfund Site known as Sauget Area 1. The UAO requires removal of the affected sediments from the creek and transfer to a TSCA compliant disposal facility. The disposal facility will be located adjacent to Dead Creek on land owned by Solutia within the segment known as CS-B. Removal of the affected sediments and transfer to the disposal cell is being performed under the UAO on an emergency basis. Figures 2-1 and 2-2 present the location and vicinity of the project site.

This report addresses the design, construction and operation of the disposal cell. The design was prepared to respond to Exhibit 2 of the UAO. The following table demonstrates how the requirements of Exhibit 2 of the UAO are addressed.

Exhibit 2	Design Report	
1. Design, Construction and Operation Requirements for Containment Cell		
a. Sediment Description	Note 1	
b. Liner System		
• Liner System Description	Section 4.1.1	Liner System Description
• Liner System Location Relative to High Water Table	Note 2	
• Loads on Liner System	Section 4.3.2	Synthetic Liner Strength
• Liner System Coverage	Section 4.1.4	Lining System Coverage
• Liner System Exposure Prevention	Section 4.1.5	Lining System Exposure
c. Foundation		
• Foundation Description	Section 3.0	Site Characterization
• Subsurface Exploration Data	Section 3.3	Subsurface Conditions
• Laboratory Testing Data	Section 3.2	Geotechnical Testing
d. Engineering Analysis		
• Settlement Potential	Section 4.2.1	Settlement Potential
• Bearing Capacity	Section 4.2.2	Bearing Capacity
• Stability of Landfill Slopes	Section 4.2.3	Cell Slope Stability
• Potential for Excess Hydrostatic or Gas Pressure	Section 4.2.6	Potential Excess Pressure
e. Synthetic Liners		
• General Information	Section 4.3.1	General Information
• Synthetic Liner Compatibility Data	Note 3	
• Synthetic Liner Strength	Section 4.3.2	Synthetic Liner Strength

• Synthetic Liner Bedding	Section 4.3.3	Synthetic Liner Bedding
f. Geocomposite Liner (GCL)		
• Description	Section 4.4.1	General Information
• Material Testing Data		
• GCL Liner Compatibility Data	Note 3	
• GCL Liner Strength	Section 4.4.2	GCL Strength
g. Liner System, Leachate Collection and Detection System		
• System Operation and Design	Section 4.5.1	System Operation & Design
• Equivalent Capacity	Section 4.5.2	Equivalent Capacity
• Grading and Drainage	Section 4.5.3	Grading and Drainage
• Maximum Leachate Head	Section 4.5.4	Maximum Leachate Head
• System Compatibility	Note 3	
• Stability of Drainage Layers Layers	Section 4.5.5	Stability of Drainage
• Strength of Piping	Section 4.5.6	Strength of Piping
• Prevention of Clogging	Section 4.5.7	Prevention of Clogging
h. Liner System, Construction and Maintenance		
1) Material Specifications	Section 6.1.1	Material Specifications
- Synthetic Liner Specifications		
- GCL Liner Specifications		
- Leachate Collection/Detection		
- System		
2) Construction Specifications	Section 6.1.2	Construction Specifications
- Liner System Foundation		
- GCL Liner		
- Synthetic Liner		
- Leachate Collection/Detection		
- System		
i. Construction Quality Control Program	Appendix F and Appendix G	
j. Maintenance Procedures for Leachate Collection/Detection System	Note 4	
k. Liner Repairs During Operation	Specification 02244	
1) Run-off Control Systems		
- Design and Performance	Section 5.5.1	Design and Performance
- Calculation of Peak Flow	Section 5.5.1.1	Calculation of Peak Flow
- Management of Collection and		
- Holding Units	Section 5.5.1.2	Collection & Holding Units
- Construction	Section 5.5.1.3	Construction
- Maintenance	Section 5.5.1.4	Maintenance

- Control of Wind Dispersal	Section 5.6	Control of Wind Dispersal
2) Closure and Post-Closure Requirements		
a) Closure Requirements		
- Closure Plans	Section 5.1	Closure Plans
- Closure Performance Standards	Section 5.2	Performance Standard
- Cover Design	Section 5.3	Cover System Description
- Minimization of Liquid Migration	Section 5.4.2	Minimization of Migration
- Maintenance Needs	Section 5.4.3	Maintenance Needs
- Drainage and Erosion	Section 5.4.4	Drainage and Erosion
- Settlement and Subsidence	Section 5.4.5	Settlement & Subsidence
- Freeze/Thaw Effects	Section 5.4.6	Freeze/Thaw Effects
b) Post-Closure Requirements	Note 5	
- Post-Closure Plan		
- Inspection Plan		
- Post-Closure Monitoring Plan		
- Post-Closure Maintenance Plan		
- Notice in Deed and Certification		

Notes:

1) Time Critical Removal Action Work Plan, Section 3.0 Sediment Chemical Analyses and Bioassays

2) Time Critical Removal Action Work Plan, Section 2.8, Groundwater Levels

3) Compatibility tests were completed and are included as Appendix J.

4) System is designed to minimize maintenance so description of maintenance is needed.

5) Post-closure will be addressed in the O&M Plan which is due 60 days after completion of cell construction.

Design data, contaminant cell construction requirements and all details referenced in the following text is located in the appendices. A brief listing of the information included in each follows:

Appendix A	Site Characterization
Appendix B	Foundation Evaluation
Appendix C	Liner System Component Design
Appendix D	Cover System Component Design
Appendix E	Technical Specifications

Appendix F	Construction Quality Assurance Manual for Installation of Geosynthetic Components
Appendix G	Construction Quality Assurance Manual for Installation of Soil Components of the Lining and Final Cover Systems
Appendix H	Geosynthetic Material Data Sheets
Appendix I	Technical Information on Performance of Geosynthetic Clay Liners
Appendix J	Material Compatibility Study

3.1 FIELD INVESTIGATION

3.1.1 1999 Investigation

A total of four borings were drilled and a piezometer installed on the property between November 8, 1999 through November 10, 1999. Two hand-auger borings were drilled on November 15, 1999. The geotechnical borings are designated GB-1 through GB-3, the piezometer is PZ-1, and the hand-auger borings are HA-1 and HA-2. Two borings, GB-1 and GB-3, were drilled to depths of about 50 ft and GB-2 was drilled to a depth of about 75 ft. Boring GB-2 was drilled deeper to estimate the vertical extent of loose to medium dense alluvium to help assess settlement and liquefaction potential of the site. The piezometer boring was drilled to a depth of about 20 ft and a piezometer was installed to that depth. A URS representative directed the field investigation, logged the borings and collected soil samples for geotechnical laboratory testing.

The work was conducted in accordance with Solutia's site policies and procedures and with a site-specific health and safety plan approved by URS and Solutia.

The borings were drilled with a CME-55 truck-mounted drilling rig owned and operated by Roberts Environmental Drilling, Inc. (REDI) of Illinois. Borings were advanced using 4¼-inch I.D. hollow-stem augers. Once the water table was encountered, typically at a depth of between 9 to 14 ft below ground surface, borings were continued using a 3⅞-inch diameter roller bit and a bentonite-based drilling mud.

Soil samples were obtained from the borings using either a 1½-inch I.D. split-spoon sampler in accordance with the Standard Penetration Test (SPT) Method (ASTM D-1586) or a hydraulically pushed thin-walled sampler (Shelby tube) to obtain "undisturbed" samples.

Sampling was made at 2½-ft vertical intervals in the upper 10 ft and at 5-ft vertical intervals thereafter. Upon completion, the borings were tremie-grouted with a cement-bentonite mixture. Drilling spoils and excess sample were placed in containers provided by Solutia along with drilling fluids displaced during grouting.

3.1.2 2000 Investigation

Two additional test borings, GB-4 and GB-5 were drilled on November 17, 2000 by Harriss Drilling Under technical supervision of URS. Borings were advanced with 9-inch O.D. hollow-stem augers using a CME-750 drilling rig to depths of 20 ft below grade. Continuous samples were obtained using either a standard split-spoon sampler (ASTM D-1586) or hydraulically pushed thin-walled tubes (ASTM D1587). It was originally planned to use only thin-walled tube samples, but due to the predominantly granular nature of the soil, split-spoon samples were primarily taken.

The borings were tremmie-grouted upon completion with a cement-bentonite mixture. Drilling spoils and excess sample were placed in containers provided by Solutia along with drilling fluids displaced during grouting.

3.1.3 Site Subsurface Profile

Field boring logs were prepared by a URS representative based upon recovered soil samples, cuttings, drilling characteristics, and field conditions. The approximate locations of the borings and the piezometer installed for this study are shown in Figure 3-1. These locations are presented against an approximate footprint of the containment cell. The logs were subsequently modified to reflect laboratory test results. Detailed logs of borings and piezometer installation are included in Appendix A. Graphic boring logs depicting generalized subsurface conditions are shown in Figures 3-2 and 3-3. Approximate elevations for the base of the Capillary Break Layer with respect to the site subsurface profile are presented in Figures 3-2 and 3-3.

3.2 GEOTECHNICAL LABORATORY TESTING

Geotechnical laboratory tests were performed on selected soil samples to characterize the index and strength properties of the subsurface soils. The tests performed included visual classification, water contents, liquid and plastic limits, unconfined compression strength and consolidation tests. The types of tests performed are given in the following table:

SUMMARY OF LABORATORY TESTS PERFORMED	
Test Name	**ASTM Designation**
Unit Weight + Water Content	D2937
Classification of Soil	D2487
Water Content	D2216
Liquid and Plastic Limit	D4318
Sieve + Hydrometer	D422
Percent Fines	D1140
Consolidation	D2435
Unconfined Compression	D2166
Unconsolidated Undrained Triaxial	D2850
Specific Gravity	D854

Results of the laboratory tests are summarized in Appendix A and are also included on the detailed boring logs. Unconfined compression tests and consolidation test figures are also attached.

3.3 SUBSURFACE CONDITIONS

The subsurface conditions at this property primarily consist of about 5 ft of low plasticity silty clayey soil in borings GB-1 through GB-3 to about 20 ft of clayey silts in PZ-1. The upper 5 ft of clayey materials is underlain by alluvial non-plastic fine sandy silts to depths of about 20 ft in borings GB-1 and GB-3. Alluvial sands underlie the sandy silts to the drilled depths. The consistency of the upper cohesive material is typically firm to stiff. The silts within the upper 20 ft are typically loose and the alluvial sands immediately below the sandy silts are loose to medium dense, and become medium dense to dense with depth. In borings GB-1 and GB-2, the relative density indicates a loose to medium dense layer exists between elevation 370 and 360 (depth between 40 and 50 ft). Below elevation 360 ft, the relative density varies between medium dense to very dense.

3.4 GROUNDWATER

The water surface was encountered between 9 and 15 ft in all borings at the time of drilling on November 8, 1999. Groundwater was observed at a depth of about 9.5 ft below grade in the piezometer boring. A piezometer reading of 9.77 ft was recorded on November 15, 1999 and 9.95 ft on November 22, 1995. A piezometer reading of 10.22 ft was recorded on December 1, 1999. In each of the 2000 borings, groundwater was first encountered at depths of about 15 ft below ground surface but rose between 7 and 8 ft (Elevation 390 to 395 ft) shortly after drilling. Further details are presented in Appendix A.

3.5 GEOLOGIC CHARACTERIZATION

The Mississippi River floodplain contains unconsolidated valley fill deposits composed of recent alluvium (Cahokia Alluvium), which overlies glacial material identified as the Henry Formation. The Cahokia Alluvium (9 recent deposits) consists of unconsolidated, poorly sorted, fine-grained materials with some local sand and clay lenses. These recent alluvium deposits unconformably overlie the Henry Formation, which is Wisconsinian glacial outwash in the form of valley-train deposits. The Henry Formation is about 100 ft thick. These valley-train materials are generally medium to coarse sand and gravel and increase in grain size with depth. Unconsolidated deposits are underlain by bedrock of Pennsylvanian and Mississippian limestone and dolomite with lesser amounts of sandstone and shale. Figure 3-4 presents a surface map of the bedrock surface within the East St. Louis area. The approximate location of the site is included in that figure. Figure 3-5 presents a cross section of the site from ground surface to bedrock.

4.1 LINER SYSTEM

The bottom liner system for the proposed containment cell will be a multi-component composite lining with leachate collection and leak detection layers. A description of the components is provided below.

4.1.1 Description

The proposed landfill liner system on the base of the cell will consist of the following layers (top to bottom):

- 18-inch thick sand layer
- Non-woven geotextile fabric
- Geonet drainage layer
- 60-mil HDPE (smooth)
- 12-inch tracked in place soil
- Non-woven geotextile
- Geonet drainage layer
- 60-mil HDPE (textured)
- Geosynthetic clay liner (GCL)
- 6-inch tracked in place soil
- Nonwoven geotextile
- 36-inch thick gravel layer
- Subgrade or compacted fill

The proposed landfill liner system for the side slopes of the cell will consist of the following layers (top to bottom):

- Non-woven geotextile fabric
- Geonet drainage layer
- 60-mil HDPE (smooth)
- Geonet drainage layer
- 60-mil HDPE (textured)
- Geosynthetic clay liner (GCL)

- Compacted fill

Figure 4-1 shows the proposed configuration of the bottom lining system. Figure 4-2 presents the proposed configuration of the side slope liner system. HDPE membrane will be manufactured by GSE, Serrot or equivalent. Geotextile will be manufactured by Mirafi or equivalent. Geonet and geogrid will be manufactured by Tenax or equivalent. GCL will be manufactured by CETCO, GSE, Serrot or equivalent. Manufacturers technical data sheets for these geosynthetics are included in Appendix H.

The subgrade soils will be graded to mirror the intended bottom grades for the completed bottom liner. An earthen berm will be constructed around the limits of the proposed containment cell to form the side walls of the cell. The upper 12 inches of the subgrade soils and all the earthen berm fill will be compacted to at least 95 percent of the soil's maximum dry density as determined by ASTM D698.

A capillary break layer consisting of 36 inches of gravel will be placed over the prepared subgrade. The gravel will conform to an ASTM C-33 gradation for coarse aggregates. The gravel will be tamped in place by the construction equipment. No additional compaction will be required. The capillary break layer will not be constructed on the containment cell side slopes.

After placing a geotextile on top of the capillary break layer, a 6-inch native fill layer will be pushed and tracked into place over the capillary break layer. Tracked in place fill shall consist of native soils with clods no greater than two inches compacted to 90 percent of Standard Proctor maximum density with moisture contents at or near optimum. The containment cell side slope berms will be constructed of compacted native fill. The tracked in place soil and the compacted fill will serve as the foundation (bedding layer) for a Geosynthetic Clay Liner (GCL). This bedding layer will have clods no larger than two inches, will be placed and compacted to at least 90% Standard Proctor Density with moisture contents at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system. The GCL will be rolled into place and overlapped with adjacent panels.

A textured 60-mil High Density Polyethylene (HDPE) liner will be placed directly over the GCL to serve as the secondary lining system. The HDPE lining panels will be heat seamed to form a continuous membrane barrier. The seaming will be either pressure or vacuum tested to verify the integrity of the seams. Mechanical tests of the seam integrity will be performed by removing test samples from the completed lining and destructively testing the samples. The lining sample locations will be patched with an extrusion welded HDPE patch.

A geonet synthetic drainage composite will be installed over the secondary lining system to serve as the leak detection layer. A nonwoven geotextile will be placed over the geonet to prevent soil intrusion into the leak detection materials. At least 12 inches of native soil will be tracked in place over the leak detection layer on the cell bottom. The tracked in place soil layer will serve as the bedding layer for the overlying geosynthetic materials. Bedding layer soils will have clods no larger than 2 inches, will be placed and compacted to 90 percent Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system. The tracked in place soil layer will not be installed on the containment cell side slopes.

A smooth 60-mil HDPE lining will be placed on the tracked in place soil layer on the cell bottom to serve as the primary lining system. The HDPE lining will be placed directly over the geonet drainage layer on the cell's side slopes. The HDPE lining panels will be heat seamed to form a continuous membrane barrier. The seaming will be either pressure or vacuum tested to verify the integrity of the seams. Mechanical tests of the seam integrity will be performed by removing test samples from the completed lining and destructively testing the samples. The lining sample locations will be patched with an extrusion welded HDPE patch.

The primary collection system will consist of a geonet and geotextile combination placed directly over the primary HDPE liner on the base and side slopes of the containment cell. At least 18 inches of sand will be placed over the geotextile/ geonet combination to form the primary leachate collection system in the bottom of the containment cell. No compaction will be performed on the sand layer. The minimum hydraulic conductivity of the sand will be 1×10^{-3} cm/sec. Rounded pea gravel will be substituted for the sand around the perimeter of the cell bottom to provide higher transmissivity for leachate removal.

Leachate collection on the cell's side slopes will be provided by a geonet/ geotextile drainage composite to prevent soil clogging. The hydraulic transmissivity of geonet is at least 5 cm/sec.

The wastes placed in the containment cell will directly contact the drainage composite on the side slopes.

As indicated previously the primary liner system on the side slopes of the landfill will be similar to that designed for the bottom. The tracked in-place clay layer beneath the primary geomembrane liner will not extend up the side slope. In addition, the primary collection system will consist of a geonet and geotextile placed directly on the primary geomembrane liner. Figure 4-2 presents this configuration.

The lining and geonet layers will be buried in anchor trenches at the top of slope around the containment cell.

The designed capacity of the containment cell is 50,000 yd^3. Calculations demonstrating this are provided in Appendix B.

4.1.2 Liner System Location Relative to the High Water Table

A piezometer installed at the proposed containment cell location has been used to monitor the groundwater depth at the site from November 1999 through April 2000. The groundwater level was observed fluctuating between 9.5 and 12.45 ft below ground surface (about elevations 392.5 and 389.55 ft). The minimum elevation of the secondary lining system will be 398.8 ft. Details of measured groundwater levels at this site are presented in Appendix A.

4.1.3 Loads on Lining System

The loads on the lining system were evaluated to determine if they could damage the lining system. The following paragraphs describe the various loads and results of calculations for those loads. Calculations demonstrating the estimated loads on the liner system are included in Appendix C.

Internal and external pressure gradients were evaluated. Two methods for the cell to experience a pressure gradient are envisioned, gas evolution from waste decomposition and barometric pressure change. The containment cell cover system will incorporate a vent system to equalize the internal and external pressure and to vent gases generated in the wastes. The overburden soil on the cover system exerts a vertical stress of over 200 psf on the cover lining. Therefore, the cover lining is not likely to balloon due to barometric pressure change of less than 3 inches of mercury. Gas generation from the waste material is anticipated to be minor since the wastes are largely inorganic or previously decomposed. The vent system will allow generated gas to exit the cell without pressure buildup. Gas vents will penetrate a minimum of 18 inches into the compacted sediments.

Lining systems may be ruptured by excessive deflection from foundation uplift or differential settlement. The 100-year flood elevation for this area is reported to be about elevation 406 ft. Based on a minimum secondary lining elevation of 398.8 ft, the lining system should not uplift as long as there is at least 4 ft of soil lining components or waste over the secondary lining. Damage to the lining system by uplift is not likely.

Differential settlement of the containment cell bottom can elongate the HDPE linings beyond their strain capacity. As shown in the settlement analyses below, the differential settlement is expected to be less than 1-inch. The bottom settlement is anticipated to assume a spherical shape. The bottom lining along the side wall embankments will settle little while the lining settlement increases to the center of the cell. The bottom settlement produces a lining strain of less than 0.1 percent. This lining strain is much less than the elastic strain limit (about 4 percent) and the plastic strain limit (about 700 percent) of the HDPE lining material. Differential settlement is not likely to damage the lining system.

Static and dynamic loads should not affect the lining system. The relatively minor waste thickness produces only minor static loads on the lining system. The loading from the wastes, cell cover, and proposed post-closure land use are well within the lining system's capability. Dynamic loads from construction and earthquakes are anticipated. Specifying a minimum cover soil thickness between any equipment and the lining will control dynamic loading of the lining system. Additionally, an engineered side slope protection layer will be incorporated in the cell where equipment traverses the slope or soil will be pushed or dumped down the slope. Earthquake accelerations in this area are minor and are not anticipated to cause any damage to the lining system. Earthquake analysis is provided in a later section of this report.

4.1.4 Lining System Coverage

The lining system at this site is designed to cover the entire footprint of the proposed containment cell. Since this facility will be an above grade disposal unit, perimeter berms will completely surround the cell. Figure 4-3 presents a plan of the site preparation required to achieve the desired disposal capacity for the site. Figures 4-4 and 4-5 present the secondary and primary geomembrane layouts for the cell. A plan view of the primary collection system coverage is shown on Figure 4-6. Figure 4-7 presents the details of the liner system proposed anchorage at the crest of the perimeter containment levee. Design calculations demonstrating the capacity of the anchor system (presented in Figure 4-7) are included in Appendix C.

Wastes will only be placed within the lined containment cell. Leachate collection and leak detection systems will control and collect all liquids from the cell. No wastes or leachate will contact the surrounding ground.

4.1.5 Lining System Exposure Prevention

Certain synthetic components in the proposed lining system can be injured by various environmental exposures. Two potentially damaging environmental exposures are sunlight and wind. Sunlight can degrade unprotected plastics and polymers. Wind can displace and damage placed materials due to uplift causing pinholes, wrinkles and weakened locations at folds. The HDPE membrane linings will not be exposed for more than about 4 to 6 months on the containment cell side slopes.

Wind damage to the geosynthetic liner systems is another potentially significant problem resulting from exposure to the elements. Damage to geosynthetics is typically due to displacement after the material has been installed. Prevention of this potential damage will be managed by placement of the succeeding soil / sand layer on the base of the landfill and via the use of sandbags on the side slopes of the cell.

Geotextile fabrics are susceptible to sunlight degradation. Several steps will be put into place to avoid extended sunlight exposure. Where possible, the geotextiles will be covered with soil as soon as possible after placement. The maximum sunlight exposure period will be 2 weeks. The geonet leachate collection layer on the cell's side slopes may not be covered with wastes for 4 to 6 months. Therefore, the side slope geonet drainage composite will be covered with an opaque plastic sheet until wastes are placed on the geonet. Sandbags will anchor the plastic sheeting over the geonet.

The GCL lining is composed of two geotextiles sandwiching bentonite clay. The GCL has sun and precipitation exposure limitations. The GCL installation will be conducted so that the GCL is covered with the HDPE lining within one day of placement.

Installation requirements for placement of GCL materials includes the following:

- Do not place GCL in the rain or at time of impending rain
- Do not place GCL in areas of ponded water
- Replace GCL that is hydrated before placement of overlying geomembrane layer
- In general, only deploy GCL that can be covered during that day by geomembrane or a minimum of twelve (12) inches of approved cover soil.

Technical information demonstrating the behavior of GCL materials is included as Appendix I.

4.2 ENGINEERING ANALYSES

4.2.1 Settlement Potential

As previously described, the soil conditions are relatively good with respect to settlement potential of the proposed containment cell. The relatively thin surficial clay and silt layers have little settlement potential. The underlying sands and silty sands are generally medium dense to dense with minor settlement potential. Regionally, the depth to bedrock is known to be about 120 ft below ground surface. These factors reduce the settlement potential at the site.

The small proportion of silt and clay soil thickness in the subsurface profile indicates that most deformation beneath the containment cell will be due to immediate settlement. Consolidation settlement will not be a significant factor at this site.

The proposed containment cell will be founded on the existing foundation soils between 395 and 407 ft elevation.

The embankment surrounding the cell will be constructed first and the lining system and wastes placed last. The embankment is expected to undergo most of its settlement during its construction. The embankment is expected to settle about 2.5 inches during its construction. The bottom lining system will settle about 2.5 inches at the center of the bottom and about 1.5 inches at the bottom perimeter. The differential bottom settlement is about 1-inch. The anticipated differential settlement of the bottom lining should produce a grade change of less than 0.05 percent. The differential settlement should not adversely affect the lining integrity or drainage. Details of this analysis are presented in Appendix B.

4.2.2 Bearing Capacity

The surficial clay and silt samples collected at the site were found to have undrained shear strengths ranging from 250 to 440 pounds per square foot (psf). Those strengths indicate soils with soft to firm consistency. The underlying sandy soils were observed to be very loose to medium dense. The limiting bearing capacity strata was found to be the surficial clays and silts. Based on the minimum undrained shear strength above, the ultimate bearing capacity of the existing subgrade soils is about 1,300 psf. Details of this evaluation are presented in Appendix B.

4.2.3 Containment Cell Slope Stability

The embankment slopes for the containment cell will be constructed from compacted natural fill obtained onsite or imported to the site. The minimum undrained shear strength of the embankment fill is estimated to be 1000 psf. The peak ground surface horizontal acceleration used in the stability calculations is 0.16g.

Slopes excavated below existing grade will have a slope angle no steeper than 3 horizontal to 1 vertical (3:1). The maximum depth of excavated slopes is about 10 ft below existing grade. For an undrained shear strength of 480 psf, the stability of this slope is estimated to have a factor of safety of greater than 20 under both static and seismic conditions. Excavations with side slopes flatter than 3:1 will have no stability concerns.

As shown in Figure 4-3, the containment cell will be constructed mostly above grade with an earthen embankment surrounding the cell. The exterior slopes of the embankment will be no steeper than 4:1. The maximum height of the 4:1 exterior embankment slopes will be about 20 ft. The factors of safety for the exterior embankment slope are 2.5 and 1.5 for the static and seismic conditions, respectively.

The interior slopes of the containment cell will be no steeper than 3:1. The maximum height of the interior slopes prior to lining system placement is about 12 ft. Factors of safety for the lining system slopes was calculated to be greater than 1.5 for a veneer of waste placed in thicknesses of less than 2 ft and in lengths of 10 ft or less on the slope.

The containment cell lining system will not be constructed over any waste materials. The containment cell cover system will have minimum and maximum surface slopes of 3 to 12 percent, respectively. The interface friction angle between the geonet drainage media and the HDPE lining was assumed to be about 16 degrees. Calculations of short-term loading and long-term loading are presented in Appendix C. Information on the typical performance of geosynthetic clay liners is included in Appendix I.

Interface friction testing will be performed by the Contractor as part of the conformance testing required by the CQA Manual. This testing will be performed in accordance with ASTM D5321 and will include the following material combinations:

- Textured HDPE / geosynthetic clay liner
- Textured HDPE / geonet
- Smooth HDPE / geonet
- Smooth HDPE / compacted soil
- Geosynthetic clay liner / compacted soil

The selected Contractor will be required to submit conformance test results within "30 days of contract award."

4.2.4 Seismic Conditions

U.S. Geological Survey (USGS) Hazard Maps show this area has a peak bedrock acceleration (PGA) of 0.1g. The earthquake magnitude for this region is estimated as 6.5. The subgrade soils at the site do not have liquefaction potential based on the PGA and magnitude estimated for this area. Details of our evaluation of seismic loading impacts are presented in Appendix A.

4.2.5 Subsidence and Sinkhole Potential

Subsidence and sinkholes are not expected in this region. Neither karstic geology nor mining activity are present in this region.

4.2.6 Potential for Excess Hydrostatic or Gas Pressure

Excess hydrostatic or gas pressure is not expected to affect the containment cell. The highest groundwater elevation observed at the site was over 8 ft below the proposed secondary lining elevation. The maximum flood elevation for this area is reportedly elevation 406. After the lining system is complete, the static weight of the soil layers in the lining system exceeds the potential hydrostatic uplift pressure. No heaving of the lining system is anticipated. Calculations demonstrating this point are included in Appendix B.

The potential for gas pressure within the containment cell is low due to the relatively low quantity of decomposable matter in the wastes compared to a sanitary waste landfill. A venting system will be incorporated into the cover system to vent excess gas or barometric pressure from within the containment cell.

4.3 SYNTHETIC LINERS

4.3.1 General Information

The primary and secondary linings in the bottom lining system and the primary lining in the cover system will be constructed with 60-mil HDPE membrane. The HDPE liners will be either textured or smooth surfaced and all will contain ultraviolet protectants. Although the HDPE manufacturer for this installation is currently undefined, manufacturers such as GSE Lining Technology or Poly-Flex Inc. produce linings meeting the requirements of the State of Illinois.

4.3.2 Synthetic Liner Strength

Two loading conditions are anticipated for the synthetic linings, soil loading on side slopes and settlement of the bottom liner system. Calculations were performed to evaluate these two conditions.

The linings on the cell's side slopes will be insulated from downdrag from the overlying waste material by a geonet drainage composite. Calculations in Appendix C (Lining Tensile Stress) for the lining stress due to the weight of soil sliding down the side slope show that the lining stress stays below the HDPE yield stress. Once wastes are placed and compacted in the cell, little down slope soil movement will be possible. This further limits the probability of lining downdrag. The cell construction specifications will prohibit dumping soil down unprotected side slopes. Where placement traffic on the side slope is required, the slope will be protected by geogrid reinforcements and additional HDPE fly sheets. As presented in Appendix C the side slope lining stress will be less than the yield stress of the HDPE geomembrane liner material. Lateral seams in the lining panels will be prohibited on the side slopes.

Settlement of the bottom lining was previously identified to be minor. The strain in the bottom lining due to settlement as presented in Appendix C is well within the elastic limit for the HDPE lining. Settlement calculations in Appendix A and Appendix B of the final design report indicate that differential settlement of the base of the containment cell after construction and waste placement will be approximately 2 inches. This translates into an elongation in the HDPE of approximately 1.3×10^{-5} in/in. Assuming an HDPE modulus of 30,000 psi the stress increase in the bottom lining is expected to be about 30 psi for each 0.1 percent strain. These values are far less than the yield strain of 13 percent for the geomembrane. As demonstrated in Appendix C the bottom linings will not be overstressed.

Synthetic lining seaming will be performed using either hot-wedge or extrusion welding. Either method will be required to provide a film-tearing bond (FTB) in the parent HDPE linings. The strength of these seams will be required to achieve at least 90 and 50 percent of the HDPE lining tensile strength in shear and peel, respectively. The seams will be destructively tested periodically as provided in the Construction Quality Assurance Plan. All seams will be tested for hydraulic integrity using vacuum, air-pressure, or electrical methods. Appendix C presents details of this analysis.

4.3.3 Synthetic Liner Bedding

Synthetic linings will be placed on select soil layers, GCL, or geonet drainage composite for the containment cell construction. Figure 4-8 presents typical sections for the bottom and slope lining system showing the proposed linings and bedding configurations. Soil bedding will be free of debris and particles prior to synthetic liner deployment. A wide range of soils, including sand, can be used as bedding material for geosynthetics. Specification 02200 - Earthwork, included in Appendix E, Technical Specifications, will be used for the geosynthetic bedding layers in the liner system. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.

4.4 GEOSYNTHETIC CLAY LINING (GCL)

4.4.1 General Information

The GCL used to construct the containment cell will be a commercially available material composed of two geotextile layers sandwiching bentonite clay granules. The hydraulic conductivity of the GCL will be no greater than $1x\ 10^{-8}$ cm/sec. Where high internal shear strength is required from the GCL, the geotextiles will be stitched together. The GCL placed on the containment cell side slopes will have an internal shear strength of 500 psf (nominal) and a tensile grab strength of at least 80 pounds. The GCL placed on the cell bottom and in the cover will have an internal shear strength of 50 psf (nominal) and a tensile grab strength of at least 50 pounds. Lateral and longitudinal seams will be completed by overlapping adjacent panels.

4.4.2 GCL Strength

The GCL material type will be tailored to meet the strength requirements of the location. The GCL used on side slopes will have 500 psf internal shear strength. Lateral seams will not be located on the side slopes, only continuous GCL panels. The lower internal shear strength GCL is suitable for all bottom and cover locations. The GCL material will not undergo any tensile loading. All tensile stresses will be transferred through the GCL via the internal shear strength to the underlying soil layers. Appendix C presents the results of this analysis.

Short-term and long-term strength of the GCL is presented in Appendix C for the loading conditions anticipated. Technical information on GCL performance is included in Appendix I.

Interface shear testing will be performed to identify site specific behavior for GCL/HDPE and GCL/compacted soil combinations.

4.5 LINER SYSTEM, LEACHATE COLLECTION AND DETECTION SYSTEM

The containment cell will incorporate a leachate collection and leak detection system. Details of the systems are provided below.

4.5.1 System Operation and Design

The leachate collection system over the primary lining system will consist of 18 inches of sand placed over a geonet/ geotextile layer on the cell bottom area. An 18-inch thick by 36-inch wide gravel drain will be located around the bottom perimeter of the cell. Figure 4-6 presents a plan view of this drain and Figure 4-9 presents a cross-section. The gravel will be encased by a geotextile filter. The minimum hydraulic conductivity of the sand will be 1 x 10^{-3} cm/sec. The gravel will be ⅜-inch pea gravel.

The side slopes will have a geonet/ geotextile drainage composite placed directly on the primary HDPE lining. The geonet will intersect the gravel berm at the bottom perimeter. The geonet will be protected during construction by pushing waste material up to the geonet to provide a 2- to 4-ft buffer between the active waste placement and the lining systems on the side slopes.

The gravel drain will be expanded to a plan dimension of 75 ft by 75 ft in a triangular shape to serve as a leachate collection sump. An HPDE pipe will extend from the sump to the top of the completed cover system for periodic leachate removal. A flush-mounted vault will protect the pipe at ground surface. The pipe will be perforated within the limits of the sump.

Leachate-collection system design will be modified to include a high-level alarm set to ensure that leachate levels in the leachate collection system are one foot or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future. Figures 4-10 and 4-11 present the plan and elevation details of the outlet.

As previously indicated the two options for removal of liquids from the cell is a vacuum truck or a dedicated submersible pump. Regardless of the method used, the high-level alarm will be installed into the collection system riser pipe with a dedicated cable. This cable will be marked with a permanent marker to establish the correct depth for the sensor and facilitate repeatability in placing the sensor in the riser pipe. Removal of liquids from each sump will be performed to ensure protection of the sensor.

If a vacuum truck is used the procedures to install and protect the high level alarm are as follows:

- Remove the sensor from the riser pipe.
- Insert the vacuum hose to evacuate the sump.
- When complete remove the vacuum hose and reinsert the sensor to the correct depth.

If a submersible pump is installed in the collection system riser, the high-level alarm will be permanently fixed to the discharge hose of the pump. In this approach the sensor will not need to be routinely removed and replaced into the pipe. However to ensure the sensor is not damaged, the dedicated cable of the sensor will be periodically attached to the discharge hose of the pump along its length. The location of the sensor will be above the intake section of the pump. Figure 4-8 presents the elevation established for the high-level alarm in the leachate collection, leak detection and the capillary relief layers.

The leak detection system will mirror the grading in the leachate collection system excepting that the elevation at the sump will drop an additional 12 inches to accommodate a gravel sump. The entire leak detection system will consist of a geonet drainage composite. A geotextile filter will be placed over the geonet where the soil layer between the primary and secondary lining systems is located. No geotextile will be placed over the geonet on the side slopes where the primary and secondary linings directly sandwich the geonet. A perforated HDPE pipe will extend from the gravel sump to the top of the completed cover system for periodic leachate removal. A flush-mounted vault will protect the pipe at ground surface. Figures 4-12 and 4-13 present the outlet pipe for the detection layer.

A 36-inch thick gravel layer will be located beneath the secondary lining system to serve as a capillary break layer. The layer will mirror the grades of the overlying detection system, draining to one corner of the bottom area. The gravel layer will be located only beneath the bottom area of the cell. A perforated HDPE pipe will extend from the gravel sump to an elevation above the 100-year flood elevation where it will exit the cell embankment. A flush-mounted vault will protect the pipe at ground surface.

Capillary break layer design will be modified to include a high-level alarm set to ensure that leachate levels in the capillary break layer are 1-ft or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future. Figures 4-14 and 4-15 present the plan and elevation detail views of the outlet pipe for the capillary break layer.

Figure 4-16 presents details of the primary collection system and leak detection riser pipes on the side slope of the cell with the required bedding within the liners.

Calculations were performed to establish the volume of sump required in the primary collection system. The sump size was based on a calculation of water balance for the cell. The hydraulic balance for the containment cell was performed using the USEPA computer program Hydrologic Evaluation of Landfill Performance (HELP), version 3.07. Calculations were performed for a short term (construction case) and long term (post closure) case. The HELP model was executed in the construction case using the above liner system configuration overlain by an 80-inch thick sediment layer without the cover system. This modeling scenario in effect models the landfill during the filling activity and represents a worst case scenario. In addition, the following conservative assumptions were made and implemented in the HELP model run:

- 100 percent of the rainfall will infiltrate into the placed fill
- The filled sediments is exposed to the weather with no temporary or permanent cover
- The permeability of the geonet is assumed to be 5 cm/sec.

The construction case simulation indicates that much less than 12 inches of leachate will be generated even under the worst case assumptions made for the evaluation.

The long-term simulation shows that most precipitation is intercepted by the cover system with virtually no leachate being produced. The primary leachate source will be from precipitation during waste placement and entrained moisture in the wastes. The simulation indicates that annual measurement and removal of leachate from the collection and detection systems will be sufficient. A peristaltic pump or vacuum truck should be sufficient to remove the collected leachate. Details of the required sump size are shown in Appendix C.

4.5.2 Equivalent Capacity of Geonet Drainage Composite

The geonet drainage composite used for all side slope collection layers and the leak detection bottom layer will have transmissivity values that are equivalent to that of a 12-inch thick sand layer with a hydraulic conductivity of 1×10^{-2} cm/sec. As demonstrated in Appendix C the geonet transmissivity is almost 2 orders of magnitude greater than the transmissivity of a sand layer.

4.5.3 Grading and Drainage

The bottom lining for the leachate collection system will slope at 3 percent beneath the sand layer toward the gravel sump and the gravel perimeter drains. The gravel drains slope at 1 percent (minimum) to a collection sump at one corner of the cell bottom. The grading for the leak detection system generally mirrors the collection system above. As demonstrated in Appendix C, based on conservative assumptions of inflow rate, the amount of leachate head that will develop in the primary collection system is considerably less than 12 inches at the farthest point from the collection sump. This calculation demonstrates that the containment cell does not require piping to achieve the regulatory performance standard for leachate development.

The sumps will be drained through HDPE pipes placed in each sump. The collection pipe will be unperforated from ground surface down to the gravel collection sump and perforated within the gravel collection sump. The piping will match the side slope grade and bend to transition from the slope to the bottom grade. End caps will be placed over the pipe ends to prevent foreign material and gravel entry.

The pipe perforations will be 1/4-inch diameter. The entire length of piping within the gravel sump will be perforated. The 3/8-inch diameter gravel will provide adequate filter action to prevent clogging of the pipe perforations.

The HELP model results indicate that leachate production will be minimal after the cover system is in place. The transmissivity of the sand, gravel, and geonet layers are adequate to rapidly transmit the leachate to the collection sump. The leachate level in each sump will be measured by installed liquid level monitors. Any liquids found in the collection piping will be removed via sump trucks or submersible pumps and placed in drums or tanks for disposal. Collected liquids will be tested to identify the presence of hazardous constituents and disposed in accordance with applicable regulations.

4.5.4 Maximum Leachate Head

The HELP model was used to predict the leachate production and head levels within the cell during construction and after closure. The HELP analysis of the closed landfill included the waste sediment layer in the evaluation of potential leachate generation for both the operating and closed conditions. Initial moisture contents assumed in the analysis were default values assigned by the program. The model results are shown in Appendix C.

The model results show that elevated leachate head may occur within the leachate collection layer during construction. The cell will behave like an open catchment and stormwater will collect on the waste surface. The construction model case assumed no stormwater pumping off the waste surface after rainfall events. As required by the specifications stormwater will be pumped off the waste surface as soon as possible to resume waste placement. The assumption of no surface water runoff and no pumping is therefore highly conservative. The construction model assumed that the cell was half-filled with wastes. Default values for initial soil moisture and hydraulic conductivity were used in the analysis. The leachate collection sump will require pump out after each rainfall event during construction. The construction model indicates the peak leachate generation rate is about 4,000 gallons per day or 2.8 gallons per minute.

The model results show that the leachate leakage into the detection layer during construction is about ¾-inch per year, which produces about 20,000 gallons of leachate in the expected 6-month construction period or about 110 gallons per day. Therefore, the leak detection layer will require checking and possibly pump out every other day during the construction period. The analysis assumed that the head in the leachate collection layer was not drawn down regularly, therefore the leachate leakage rate is conservative.

The model results show the leachate and leak production rates fall substantially after the cover system is installed over the cell. Leachate development and leak production are essentially zero after the cell water balance has reached equilibrium.

Practically 100 percent of stormwater falling on the closed landfill is managed by the cover system system via evapotranspiration. Stormwater that does infiltrate the cover system is absorbed by either the topsoil layer or the contained sediments.

Some leachate production will continue for several months after the cell is covered due to continued gravity drainage of the placed sediments, however this is expected to diminish with time. Installed liquid level controls will continuously monitor the leachate and leak collection sumps. Periodic inspections (weekly or monthly) will be conducted until the production rate has reduced. Annual checks will be conducted thereafter.

Leachate-detection system design includes a high-level alarm set to ensure that leachate levels in the leachate detection system are one foot or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future.

4.5.5 Stability of Drainage Layers

The containment cell drainage layers will support the loads in the system. The maximum vertical stress expected for the leak detection layer is about 2,500 psf. The geonet drainage composite is rated for vertical loadings over 20,000 psf. Therefore, the leak detection layer will not be affected by the loading.

The leachate collection system will have a maximum vertical stress of about 2,300 psf. The sand and gravel layers can support many times that vertical stress without crushing. Therefore, the leachate collection layer will not be affected by the loading.

The drainage layers on the side slopes will be geonet drainage composites. These layers will not support significant loading by soil or equipment moving down the slope. Therefore, additional engineering and construction measures are required to perform the cell construction and waste placement. Reinforced ramps to carry the soil and equipment loads may be used. A geogrid reinforcement with an underlying HDPE slip sheet will insulate the geonet and linings from tensile downslope loads. Calculations for the reinforcement are shown in Appendix C.

The geonet drainage composite on the side slopes will be protected during waste placement by pushing the wastes up to the slopes with a minimum separation of 2 to 4 ft between the equipment and side slopes. The wastes will be placed sequentially from the cell bottom to the top and little movement of the wastes on the side slopes is anticipated. Geotextiles used on the drainage composite can commonly reach 50 percent strain before failure and the geonet strain capacity is larger yet. The movement of the wastes due to settlement is not likely to exceed several percent. Therefore, the geonet drainage composite will perform adequately on the side slopes.

4.5.6 Strength of Piping

Piping in the containment cell is limited to the sump drains in the leachate collection, leak detection, and capillary break layers. In all three installations, 6-inch diameter HDPE piping with a SDR of 11 will be used. The worst case loading condition is anticipated to be a wheel loading from a construction vehicle. The tire pressure and width were assumed as 50 psi and 12 inches, respectively. The depth of soil cover was 1-ft. A 1,000 psi soil modulus is representative of a soft clay material. The proposed piping provides factors of safety greater than 7 for the loading condition. The proposed piping will provide acceptable service in the containment cell. The pipe strength calculations are provided in Appendix C.

4.5.7 Prevention of Clogging

Clogging in the leachate collection and leak detection systems is unlikely to affect the performance of the systems. The systems will receive their highest loads during the waste placement with the loading expected to fall to near zero after the cover placement as reported in the Maximum Leachate Head section. The relatively short performance period for the system reduces the effect of clogging on the long-term performance of the cell.

A geotextile and 6-inch sand layer protect the underlying sand and gravel drainage layers in the leachate collection system from clogging due to the waste materials. A geotextile over the geonet drainage composite on the side slopes protects geonet from clogging with the waste materials. Clogging the geotextile on the side slope should not be a concern since the leachate will continue to flow down slope to the bottom collection layer without applying head to the lining system. Calculations indicate that the average opening size for the geotextile selected to separate the contained sediments and soils from the leachate collection system is appropriate for the expected grain size of the Dead Creek sediments.

The hydraulic capacity of the leachate collection and leak detection systems is many times greater than the highest demand placed on the layers. Minor clogging is not expected, but the capacity of the systems should provide adequate liquid drainage. After the cell is covered, the flows are nearly zero and clogging will not significantly limit the systems' performance. An analysis of geotextile clogging is presented in Appendix C."

In our opinion, the use of pipes as the primary leachate collection system will not improve the efficiency of the leachate collection and removal. Based on our experience we do not believe that installation of a piping system for leachate collection is appropriate for the following reasons:

- Potential clogging of pipe perforations.
- Carrying capacity of the pipes is much less that the drain system currently designed for the landfill.
- If a section of the pipe does become clogged, that portion of the collection system is rendered useless until detected and cleaned.

The sand and gravel layer proposed for the Primary LCRS (in addition to the geonet layer proposed for this system) is designed with a high degree of tolerance for clogging. If an area of the primary system was to experience some encrustation or localized clogging, leachate will not be prevented from entering the LCRS geonet layer or the gravel sump for removal from the system. Leachate will not accumulate over the system, the liquid will continue to seek the lowest possible level by flowing around the zone of reduced permeability.

4.6 MAINTENANCE PROCEDURES FOR LEACHATE COLLECTION & DETECTION SYSTEMS

Leachate collection and leachate detection systems were designed to be low maintenance systems. No maintenance is required to ensure that drainage occurs because both systems drain by gravity to their respective collection sumps. Vacuum trucks will be used to remove accumulated liquids from both sumps so no pump maintenance is required. Riser pipes and perforated pipe sections in the collection sumps are large enough to allow pressure washing should fouling occur.

5.1 CLOSURE PLANS

The containment cell will incorporate an impermeable cover to reduce infiltration into the completed cell. The cover will be sloped to promote stormwater run-off and will incorporate structural features to direct and control the run-off from the elevated cover. The cover slope also provides for potential settlement of the contained wastes. The impermeable cover will be constructed to completely encapsulate the materials placed within the cell.

5.2 CLOSURE PERFORMANCE STANDARD

The cover system of this landfill is designed to:

- minimize the need for further maintenance, and
- control, minimize or eliminate the post closure escape of materials within the landfill to the ground or surface water surrounding the site.

The closure plan provides an engineered cover system that controls and routes stormwater to reduce cover erosion. The cover will incorporate an impermeable composite lining system that will reduce the infiltration into the wastes and subsequent leachate generation. A geonet drainage composite will intercept and route water infiltrating the cover soil layer to reduce the head on the cover lining system. The cover soil layer will be 24 inches thick to provide adequate rooting depth for the grassing on the cover. The grassing will reduce soil erosion.

A sand layer will be placed over the completed waste fill to provide a gas permeable zone for a gas vent system through the cover system. Vent pipes will penetrate the cover system to provide relief for gases generated by the wastes and to vent barometric pressure changes.

The impermeable cover composite lining system substantially reduces liquid infiltration into the wastes and subsequent leachate generation. The cover system will be installed after all waste materials have been interred there.

5.3 COVER SYSTEM DESCRIPTION

The landfill cover is designed to prevent infiltration of stormwater into the waste material and promote rapid run-off of stormwater during rainfall events. At a minimum, the cover system will include the following from bottom to top:

- 6 inches of tracked in-place sand
- geosynthetic clay liner
- 60-mil HDPE geomembrane (textured)
- geotextile fabric
- geonet drainage layer
- geotextile fabric
- 24 inches of soil and drainage layer to support the vegetation cover

5.4 COVER DESIGN

5.4.1 General

The cover system for the proposed containment cell will be a multi-component composite lining with gas collection and subsurface drainage layers. The proposed cover system is designed to provide a degree of impermeability equivalent to the bottom lining system. Surface grades for the containment cell side slopes are no steeper than 4:1 for ease of mowing and maintenance. The central cover area will have a surface slope between 3 and 12 percent depending on the waste volume. A raised berm around the central cover area routes stormwater to a precast downlet drop box and outlet channel at the toe of the 4:1 side slope. The total landfill plan area is about 5.4 acres. Figure 5-1 shows the proposed configuration of the cover system. Figure 5-2 shows a cross section of the proposed cover system. A description of the cover system components is provided below. The components are described in a bottom to top order.

The subgrade for the cover system will be the waste materials. The waste materials will be graded to mirror the final surface grades on the cover. Clean fill will be used if needed to provide the grades if there is not enough waste fill to meet the required grades. A 6-inch thick sand layer will be pushed and tracked into place over the graded subgrade to serve as the bedding for the linings and serve as a gas collection layer. Four gas vent structures will be distributed around the cover to vent the sand layer to the atmosphere. The vent stack will be constructed of 6-inch diameter PVC piping capped with a hood to prevent precipitation infiltration. The portion of the vent stack below the lining elevation is slotted to provide pneumatic connection to the sand layer. Each vent will include a 20-ft by 20-ft geonet layer to create an enhanced collection zone around the vent. Each vent stack excavation will be backfilled with gravel to provide a stable foundation. Each vent pipe passes through a fabricated boot in the HDPE lining to prevent seepage from entering the cell. Figure 5-3 presents a detail of the vent structure.

The 6-inch sand layer will be the bedding layer for the GCL materials. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system. Specification 02200 - Earthwork, included in Appendix E, Technical Specifications, of the Design Report, will be used for control of placement of the geosynthetic bedding layers in the liner system.

A GCL will be placed over the sand layer. The GCL will be rolled into place and overlapped with adjacent panels. The GCL used in the cover will be a commercially available material composed of two geotextile layers sandwiching bentonite clay granules. The hydraulic conductivity of the GCL will be no greater than 1×10^{-8} cm/sec. The GCL will have an internal shear strength of 50 psf (nominal) and a tensile grab strength of at least 50 pounds. Lateral and longitudinal seams will be completed by overlapping adjacent panels.

A 60-mil High Density Polyethylene (HDPE) lining will be placed directly over the GCL. The GCL and HDPE composite lining system extends over the entire lined waste cell and is buried in an anchor trench just outside the limits of the bottom lining anchor trench. The HDPE lining panels will be heat seamed to form a continuous membrane barrier. The seaming will be either pressure or vacuum tested to verify the integrity of the seams. Mechanical tests of the seam integrity will be performed by removing test samples from the completed lining and destructively testing the samples. The sample locations from the lining will be patched with an extrusion welded HDPE patch. The primary lining in the cover system will be constructed with 60-mil

HDPE membrane. The HDPE lining will be textured and will contain ultraviolet protectants. Although the HDPE manufacturer for this installation is currently undefined, manufacturers such as GSE Lining Technology or Poly-Flex Inc. produce linings meeting the requirements of the State of Illinois.

A geotextile/ geonet/ geotextile drainage composite will be placed directly on the HDPE lining to serve as a subsurface drain. The drainage composite will extend over the entire cover area and connect to perforated piping at the edge of the cover area. The perforated piping is connected to gravel covered outlets at ground surface to drain the collected water. The gravel prevents access to the drainage piping by animals.

A 24-inch earthen cover soil layer will be constructed over the geosynthetic drainage composite layer to provide a vegetated cover. The cover soil material will be a native soil suitable for grass growth and with a maximum particle size of ¼-inch. The cover soil layer will be compacted to at least 90 percent of the fill's maximum dry density as determined by ASTM D-698 to provide stability to the cover soil for mowing and maintenance. The grassing will be with grass seed mixes appropriate for Illinois, specifically IDOT Section 250 Seed Mixture Class 1.

HDPE membrane will be manufactured by GSE, Serrott or equivalent. Geotextile will be manufactured by Mirafi or equivalent. Geonet and geonet will be manufactured by Tenax or equivalent. GCL will be manufactured by CETCO, GSE, Serrot or equivalent. Manufacturers technical data sheets for these geosynthetics are included in Appendix H. Manufacturers technical data sheets for all geosynthetic components including Geomembrane, GCL, geotextile, geonet and geogrid are included as Appendix H of the Design Report.

5.4.2 Minimization of Liquid Migration

The proposed cover design provides a substantial long-term minimization of liquid migration through the cover system. Modeling of the cover system was performed using HELP. The model results indicate that the infiltration through the cover system is less than 1/1000 of 1 percent of the total precipitation falling on the cover system. The HELP results are provided in Appendix C.

5.4.3 Maintenance Needs

The proposed cover system was designed to minimize the amount of maintenance and to allow easy maintenance. The cover system incorporates relatively gentle slopes for ease of mowing. The lower portions of the side slopes include rip rap armoring to reduce erosion of the side slopes during flooding events in Dead Creek. The berm around the central cover area reduces the amount of stormwater flowing down the side slopes, reducing the erosion potential. The central cover area slopes are mild to reduce stormwater run-off velocity and erosion. The gravel covered subsurface drains on the cover help keep animals out of the drainage collection system to avoid gnawing injury to the system.

5.4.4 Drainage and Erosion

The cover system design incorporates a berm around the central cover area to route stormwater off the cover through an armored downchute. The velocity of sheet flow run-off on the cover varies between 0.25 and 0.44 ft per second for slopes between 3 and 12 percent, respectively. Grassed surfaces are appropriate for these flow velocities. Calculations for the sheet flow velocities are provided in Appendix D.

The geosynthetic drainage composite used as the subgrade drain has a transmissivity of 9×10^{-1} cm^2/sec. The geonet will be a 3-dimensional HDPE net between two layers of non-woven geotextile fabric. The drainage composite will directly contact the underlying HDPE lining. Calculations in Appendix C show that the geotextile will resist clogging by the native sandy silt soils expected for use as the cover soil layer.

Free drainage of the subgrade drain is confirmed in the HELP model calculations. The liquid head in the subgrade drain does not exceed 4.2 inches under peak daily conditions. The average annual head in the subgrade drain is 0.007 inches. The HELP model results are provided in Appendix C.

Free drainage of the cover surface is maintained by adequate drainage course slopes. The central cover area will have a minimum slope of 3 percent. A raised earthen berm around the entire central cover area will form a 1-ft deep swale to route the stormwater flow to the single stormwater drop structure. The swale slope will be 1 percent. A combination of precast concrete drop boxes and HDPE piping will carry the stormwater down the exterior slope of the cell. A grassed lined outlet channel will be constructed at the foot of the 4:1 (H:V) slope to dissipate the hydraulic energy and route the stormwater to Dead Creek. These appurtenant structures are designed to handle a 32 cfs peak flow. The stormwater calculations for the cover system are provided in Appendix D.

5.4.5 Settlement and Subsidence

The foundation soils beneath the proposed containment cell are primarily sandy soils with little potential for consolidation or creep settlement. Most settlement will be immediate. The settlement potential for the cell is described in a previous paragraph. Settlement potential for the soil lining is minimal due to the components receiving moderate compactive effort and the total overburden weight being minor.

The wastes placed in the cell are largely inorganic soils with limited digestible material. The wastes will be dried prior to placement in the cell and they will be compacted during placement. The degree of compaction will not be specified for waste placement. Consolidation of the waste mass is not likely to be significant. Consolidation testing on the proposed wastes has not been performed. Correlations for consolidation potential generally show that settlement potential decreases as the material's liquid limit and moisture content decrease. In addition, the mechanically compacted soil should behave as an over-consolidated soil that has significantly less settlement potential than a normally-consolidated soil. The 16-ft maximum waste thickness makes it unlikely that the overburden stress will approach the normally-consolidated range for the wastes, therefore the over-consolidated settlement behavior should be valid for this analysis. The duration of waste placement will allow some of the potential settlement to occur prior to cover placement, further limiting the cover settlement. The cover system settlement is estimated as about 1-inch at the center of the cover. That deflection produces no measurable reduction in the cover grade. The waste consolidation calculations are provided in Appendix D.

The potential settlement for the foundation and wastes will not measurably alter the surface grades of the cover system. The precipitation runoff should not be affected by any cover settlement and the infiltration predicted by the HELP modeling should be valid for the life of the cell.

5.4.6 Freeze/Thaw Effects

The frost penetration depth in this region is about 3 ft. The GCL in the cover system will be 2 ft below ground surface. The cover system GCL will be subject to freeze/thaw action.

Freeze/Thaw action can reduce the effectiveness of impermeable soil barriers. This cover system will use a GCL as the impermeable soil barrier. Testing performed by GeoServices Inc. for James Clem Corporation in 1988, showed that the GCL becomes about one-half order of magnitude more permeable when subjected to freeze/thaw cycling. The permeability of the GCL used in the HELP modeling does include this reduction for the freeze/thaw effects. The infiltration rate through the cover system should represent long-term performance.

5.4.7 Anchorage

The anchor trench around the perimeter of the landfill will be excavated and the liner segments placed such that the field welds will run up and down the side slopes of the berms. The liner will be placed into the anchor trench, the backfill soils will be placed and then compacted. A detail of the anchorage for the geosynthetic liner is shown on Figures 5-4 and 5-5.

5.5 RUN-OFF CONTROL SYSTEMS

Stormwater run-off control during containment cell construction and filling will be performed as follows.

5.5.1 Design and Performance

During construction, storm water in the cell will be pumped from the cell and discharged to Dead Creek. During sediment transfer, storm water in the cell will be treated, as required, and discharged. For most of the waste placement process, stormwater is completely contained within the lined cell. All stormwater contacting the placed sediments will be handled by pumping to the filter dam at the downstream end of Creek Segment B.

During waste placement, the waste fill will be graded to create a collection sump from which stormwater will be pumped. Since the waste placement period is relatively short (about 6 months), the design storm for the open cell is a 1-year, 24-hour event. The rainfall amount is 2.71 inches. The stormwater volume from that storm is about 222,000 gallons. Approximately ¼ of the cell area would need to be left with a 1-ft depth to accommodate that stormwater volume.

For a 25-year, 24-hour storm, the rainfall amount is 6.02 inches. The stormwater volume from that storm is about 495,000 gallons. Approximately ¼ of the cell area would need to be left with a 2-ft depth to accommodate that stormwater volume.

Figure 5-4 presents the detail for run-off control during placement within the landfill. To reduce the stormwater volume, impermeable covers may be placed over the wastes to prevent contact with the stormwater. Stormwater ponded on the impermeable covers will be discharged to Dead Creek. As the waste elevation approaches the perimeter berm elevations, impermeable covers will be required over the wastes to limit stormwater contact.

Once the cover is installed, sedimentation will be controlled using best management practices. After vegetation is established there is no need to control runoff from the cell. Storm water runoff will be routed to a grassed lined outlet channel north of the cell that discharges to Dead Creek. Drawings for this swale, which is designed to handle a 25 year, 24 hour storm, are included as Figures 5-1 and 5-6 in the Design Report.

Perimeter ditching and a controlled downlet structure for stormwater falling on the landfill are incorporated into the design. At the confluence of the two swales located at the northwest corner of the landfill (at the top of the berm) stormwater will flow into two interconnected drop inlets placed at different elevations. The first pre-cast inlet will be placed at the confluence of the two swales and the second inlet will be placed immediately to the north and set at a lower elevation. The stormwater will then flow out of the lower inlet into the grassed lined channel with an ultimate outfall to Dead Creek, located east of the landfill. In addition, rip-rap will be added to the grassed lined channel, as appropriate, to provide further erosion protection.

5.5.1.1 Calculation of Peak Flow

Two methods were used to estimate the peak flow from the cover system; the Rational Method and TR-55. The calculations and the design of the inlet drainage structures are based on a 25-year, 24-hour storm event. Rainfall frequency distributions were taken from *Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois*, by Huff and

Angel. The original calculations for the stormwater system were performed using the TR-55 model. To estimate the time of concentration for sheet flow using TR-55, the model uses the following Manning's kinematic equation to compute T_c,

$$T_c = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,S^{0.4}}$$

Where:

T_c = Travel time (hr)
n = Manning's roughness coefficient
L = Flow length (ft)
P_2 = 2-year, 24-hour rainfall (in),
S = Slope of hydraulic gradient line (land slope, ft/ft)

The 2-year, 24 hour storm event is recommended for sheet flow distances that are less than 300 feet by TR-55. The peak flow for the 25-year, 24-hour storm is 27 cfs. The rational method was also used to determine the total runoff from the cover system and to size the inlet system. Based on the Rational method, a peak flow from the cover system is calculated to be 32 cfs. The cover system appurtenant structures were designed to handle the 32 cfs peak flow. These calculations are included in Appendix D.

At the confluence of the two swales located at the northwest corner of the landfill (at the top of the berm) stormwater will flow into two interconnected drop inlets placed at different elevations. The first pre-cast inlet will be placed at the confluence of the two swales and the second inlet will be placed immediately to the north and set at a lower elevation. Collected stormwater will flow out of the lower inlet into the grassed lined drainage ditch with an ultimate outfall to Dead Creek, located east of the landfill. In addition, rip-rap will be added to the grassed lined channel, as appropriate, to provide further erosion protection.

5.5.1.2 Management of Collection and Holding Units

The waste cell will be actively managed by the construction contractor to minimize delays to the work progress. The cell will be pumped out as soon as possible to resume the waste placement. Tank trucks, mobile tanks, or lined pools may be used to store stormwater and leachate that has contacted the wastes. The liquids will be treated onsite and discharged or will be transported to a POTW for treatment and disposal.

5.5.1.3 Construction

The stormwater run-off control system will be constructed primarily of waste materials and will be contained within the lined containment cell. The run-off control system will incorporate requirements to maintain storage capacity in a portion of the waste fill area or provide impervious barriers to avoid waste contact. The requirements for run-off control are contained in Appendix D. A construction quality control program will only assure the retention volume is met since the configuration changes daily and the cell is lined. When impervious linings are used, the retention volume may be reduced in proportion to the area covered.

5.5.1.4 Maintenance

The run-off control system will require daily maintenance to accommodate the daily filling progress. Maintenance activities will be limited to providing the required retention volume within the waste area.

5.6 CONTROL OF WIND DISPERSAL

The waste materials will consist primarily of soil and organic materials. The materials may produce dust if allowed to become too dry. Dust will not be allowed from the operations and the waste fill will be sprinkled with water to reduce any dust generation.

5.7 POST-CLOSURE RUN-OFF

Surface water run-off will be controlled by landscaping and diversion structures to promote run off away from the landfill. Erosion control will be maintained by appropriate landfill contouring and establishment of grass vegetation to stabilize the soil cover.

Surface run-off occurring after closure will not contact the waste material and therefore will be considered non-contaminated. Following closure of the landfill, stormwater will be discharged directly off-site to Dead Creek.

5.8 DRAINAGE STRUCTURES

Drainage structures used in the engineering design for stormwater management may include half-round corrugated metal pipe (CMP) channels, earth berms and channels, and rip rap channels. Drainage structures will be specified that adequately manage the volume of stormwater. Figure 5-1 presents a plan view of the final cover and stormwater management system for the cell. Earth berms and channels may be used to control on-site surface waters. Figure 5-5 presents the final cover system runoff control berm and swale. A cross section of the grassed lined stormwater channel located north of the landfill is shown in Figure 5-6. Figure 5-8 presents a profile of the landfill drop structure which routes collected stormwater to the grassed lined channel. Figure 5-9 presents the outlet detail for the drop structure to the grassed lined channel (Figure 5-6). Figure 5-10 presents the profile of the outlet channel at Dead Creek.

6.1 SPECIFICATIONS

6.1.1 Material Specifications

Specifications for the materials proposed for the liner and cover systems are included as Appendix E. Details of material thicknesses, strength and physical properties are presented for:

- geomembrane liners and covers
- geosynthetic clay liners
- geotextiles, geonets and geogrids
- pipes and other appurtenances

In addition, material requirement for compacted fill, drainage media, tracked in-place clay and vegetated cover soil are also included.

6.1.2 Construction Specifications

Requirements for the installation or construction of each element of the landfill liner and cover system are included in the specifications in Appendix E. The specifications include construction requirements for:

- inspection prior to deployment or installation of geosynthetic materials
- placement/deployment procedures
- bonding and material interface/overlap requirements and
- procedures for protection before, during and after placement.

6.2 CONSTRUCTION QUALITY CONTROL/QUALITY ASSURANCE

As required by the specifications for the construction of this Landfill, a two step process will be used to document that the finished product was constructed in accordance with the Plans and Specifications. Construction quality control will be performed by the Contractor to verify the work. Construction quality assurance will be the responsibility of the Owner. An independent registered professional engineer will monitor the placement, construction or installation of the liner and cover systems. Requirements for construction quality control are included in the Specifications for each component of the landfill in Appendix E. Solutia's Quality Assurance Manual for the Installation of Geosynthetic Lining Systems is presented in Appendix F. Solutia's Quality Assurance Manual for the Installation of the Soil Components of the Lining and Final Cover Systems is included as Appendix G.

6.3 REPAIRS DURING CONSTRUCTION

During placement of the sediments and soils into the containment cell observations will be performed to ensure no damage occurs to the geosynthetic materials. If one of the synthetic materials is damaged the contractor will be required by the Construction Manager and CQA Inspector to immediately repair the damage. The means and methods for effecting these repairs will be the same as the methods used for construction. This requirement will include implementing the CQC requirements of the Specification and the CQA plan.

6.4 OPERATION AND MAINTENANCE REQUIREMENTS

Post closure requirements for the landfill will be identified in the operation and Maintenance Plan to be submitted by Solutia within 60 days of the start of construction.

Access roads are provided to facilitate placement of sediments within the containment cell. Figure 6-1 presents the location of the ramps. Geogrids and HDPE subsheets will be used to prevent damage to the liner system. Figure 6-2 presents the section detail of these ramps.

EPA and Illinois regulations require that a landfill's liner and leachate collection system be constructed of materials that are chemically resistant to the wastes managed in the landfill and the leachate expected to be generated. Solutia has selected HDPE based on the results of chemical compatibility testing performed by the manufacturer. Solutia has selected Geosyntec to perform a site-specific compatibility evaluation of the materials proposed for this disposal unit. Geosynthetic materials (geomembrane and geotextiles) will be tested in accordance with EPA's proposed 120-day accelerated-life Test Method 9090 "Compatibility Test for Waste and Membrane Liners." A copy of that report is included as Appendix J.

Compatibility of soil components proposed for the disposal cell is also under evaluation. Compacted clay and geosynthetic clay liner materials will be evaluated using the EPA 9100 test procedure to identify changes in material properties after exposure to the leachate. The results of this evaluation are also included in Appendix J.

The engineering analyses and calculations used in the design of the landfill are presented in the following appendices:

- **APPENDIX B - FOUNDATION EVALUATION**
  - Containment Cell Capacity
  - Bearing Capacity
  - Settlement Potential
  - Slope Stability

- **APPENDIX C - LINER SYSTEM COMPONENT DESIGN**
  - Gravel Drain Sizing
  - Pipe Loading
  - Geotextile Clogging Potential
  - GCL Loading Calculations
  - Lining Tensile Stress
  - Sump Sizing
  - Access Ramp Stability
  - HELP Evaluation
  - Geonet Equivalent Performance
  - HDPE Elongation Calculations
  - Liner System Stability Analysis
  - Anchor System Design
  - Geotextile Separation Fabric Design

- **APPENDIX D - COVER SYSTEM COMPONENT DESIGN**
  - Cover System Stormwater Control
  - Run-off Velocity/Sheet Flow
  - Waste Consolidation

FIGURES

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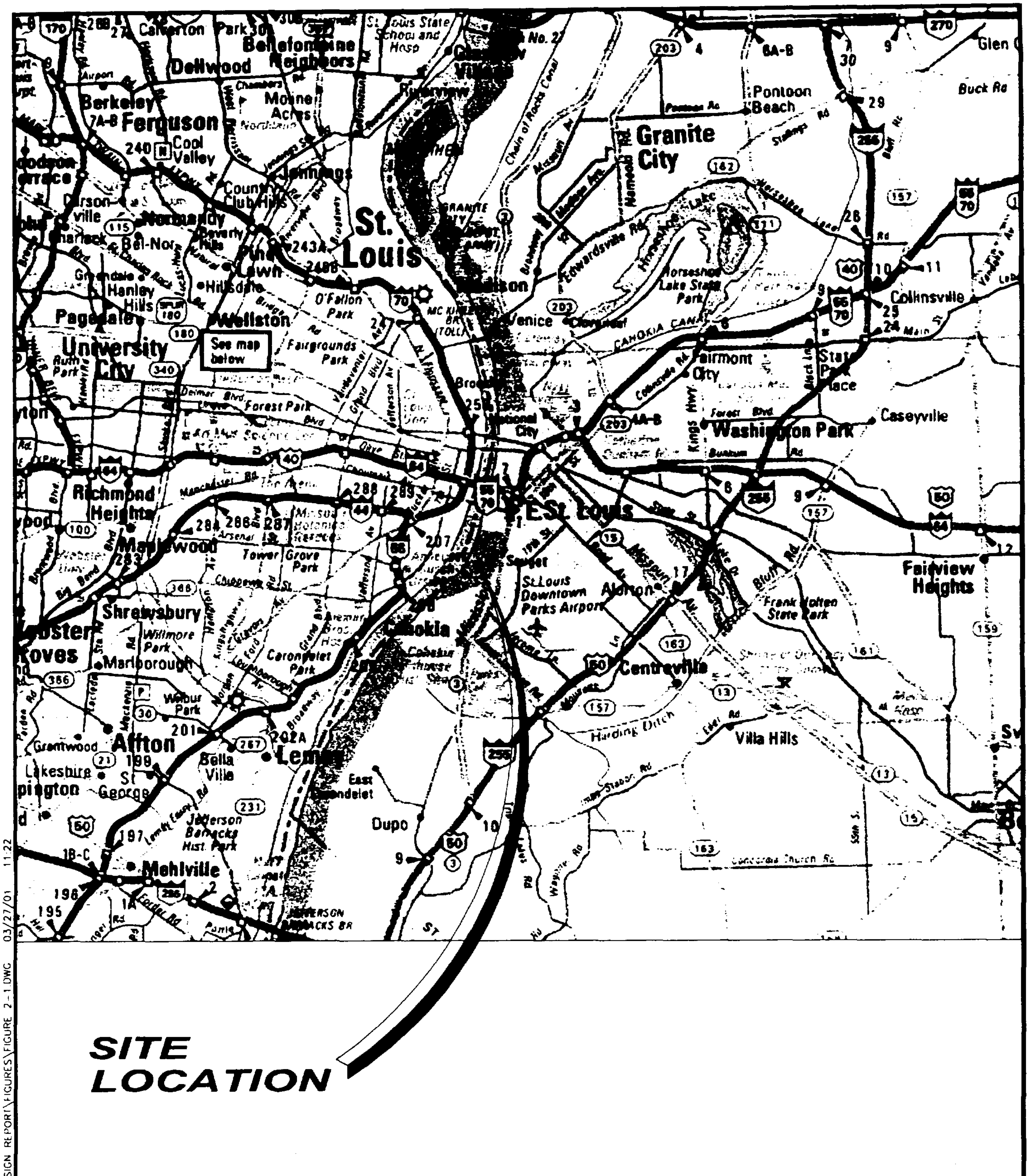

PREPARED FOR: SOLUTIA

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URS Greiner Woodward Clyde
A Division of URS Corporation
7650 W. Courtney Campbell Causeway
Tampa, Florida 33607-1462
Tel: 813.286.1711 Fax: 813.287.8591

Drawn: W. WEBER

Design: GARY WANTLAND

Checked: GARY WANTLAND

Date: APRIL 2, 2001

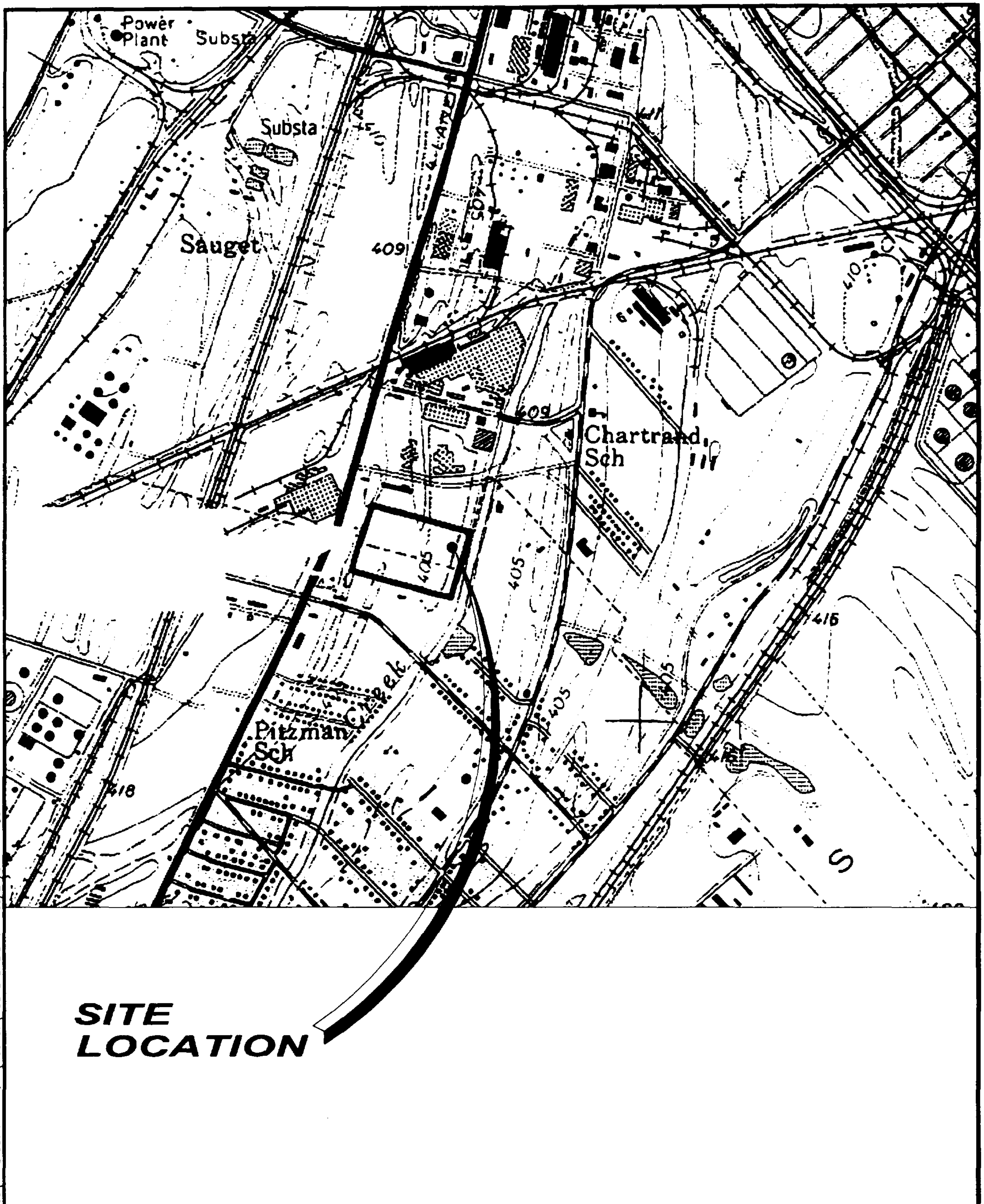
PROJECT NAME

SOLUTIA INC.
SAUGET AREA 1

DRAWING TITLE

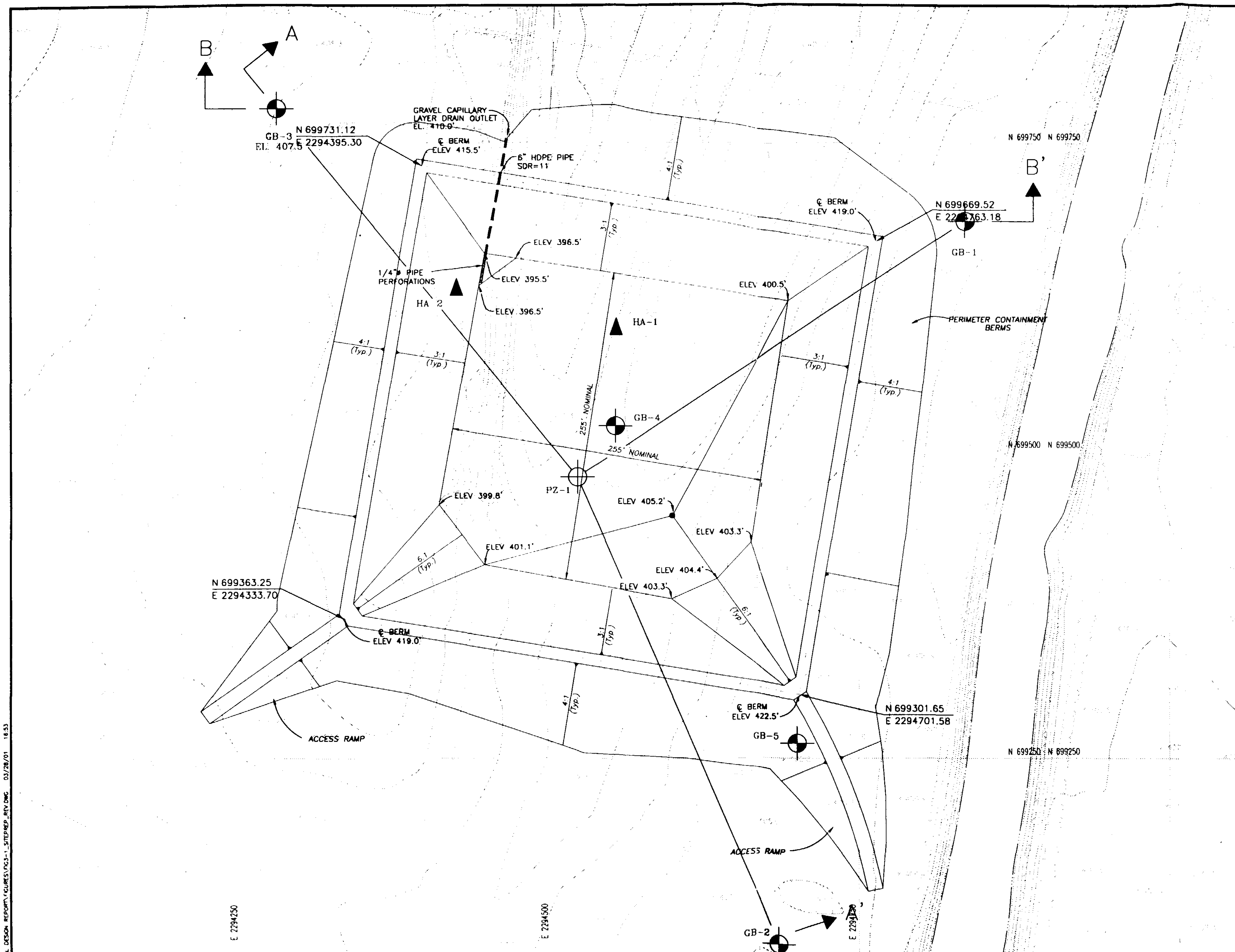
SITE LOCATION

FIGURE 2-1



S:\C10000\4000\00\FINAL DESIGN REPORT\FIGURES\FIGURE 2-2.DWG 03/27/01 11:23

PREPARED FOR: SOLUTIA URSGWC JOB NUMBER: C100004051.00 **URS Greiner Woodward Clyde** *A Division of URS Corporation* 7650 W. Courtney Campbell Causeway Tampa, Florida 33607-1462 Tel: 813.286.1711 Fax: 813.287.8591	Drawn: W. WEBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1 DRAWING TITLE **PROJECT VICINITY MAP**	FIGURE 2-2



Notes:
1. Perimeter Containment Berms shall be constructed with compacted materials consisting of the following classification per ASTM D2487: SC, SP-SM, SC-SM, CL or CH.

2. Soils shall be compacted to 95% of Maximum Standard Proctor dry density at moisture contents of 2% below optimum moisture to 3% above optimum moisture.

REDUCED DRAWING – VERIFY SCALE

REV	DESCRIPTION OF REVISION	BY	DATE

DESIGNED BY: M. BRUNGARD
DRAWN BY: G. BRADFORD
CHECKED BY: C. WANTLAND
PROJECT MANAGER: C. WANTLAND
DATE: APRIL 2, 2001

URS
URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

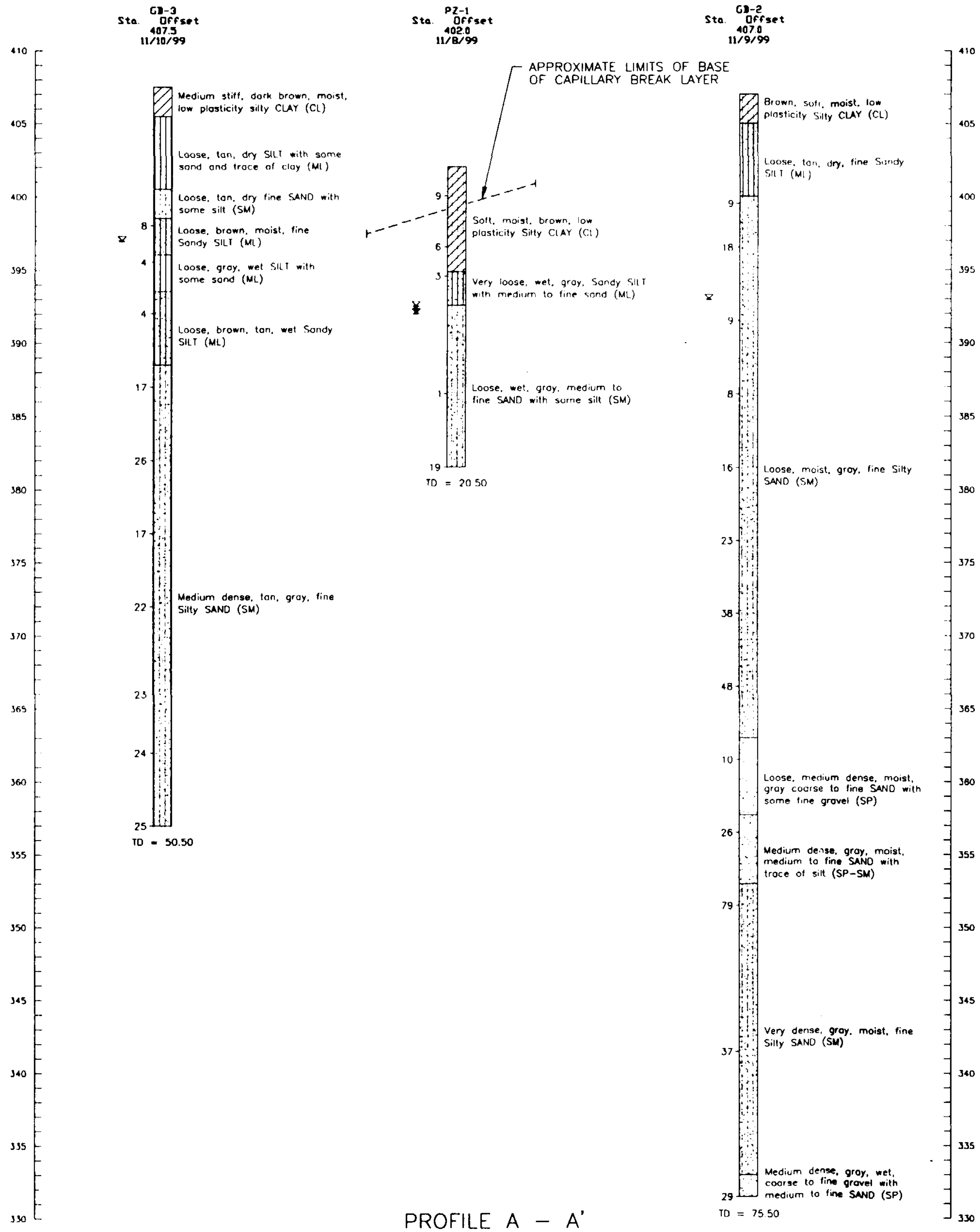
SOLUTIA INC.
SAUGET AREA 1
CAHOKIA, ILLINOIS

BORING LOCATION

PROJECT NUMBER
C100004051.00

FIGURE
3-1

S:\C10000\40001\4051.00\FINAL DESIGN REPORT\FIGURES\FIG3-1_SITEPREP_REV.DWG 03/28/01 16:53



PROFILE A – A'

ENGINEERING CLASSIFICATION

I COHESIONLESS SOILS

DESCRIPTION	BLOW COUNT "N" *
VERY LOOSE	0 TO 4
LOOSE	5 TO 10
MEDIUM DENSE	11 TO 30
DENSE	31 TO 50
VERY DENSE	OVER 50

* BLOWS PER FOOT MEASURED USING 140 POUND WEIGHT HAVING A FREE FALL OF 30 INCHES

II COHESIVE SOILS

DESCRIPTION	UNCONFINED COMPRESSIVE STRENGTH, QU, TSF	BLOW COUNT "N"
VERY SOFT	<1/4	0 TO 2
SOFT	1/4 TO 1/2	2 TO 4
MEDIUM STIFF	1/2 TO 1	4 TO 8
STIFF	1 TO 2	8 TO 15
VERY STIFF	2 TO 4	15 TO 30
HARD	OVER 4	OVER 30

TERMS CHARACTERIZING SOIL STRUCTURE

SLICKENSIDED	HAVING INCLINED PLANES OF WEAKNESS THAT ARE SLICK AND GLOSSY IN APPEARANCE.
FISSURED	CONTAINING SHRINKAGE CRACKS, FREQUENTLY FILLED WITH FINE SAND OR SILT; USUALLY MORE OR LESS VERTICAL.
LAMINATED	COMPOSED OF THIN LAYERS OF VARYING COLOR AND TEXTURE.
INTERBEDDED	COMPOSED OF ALTERNATE LAYERS OF DIFFERENT SOIL TYPES.
CALCAREOUS	CONTAINING APPRECIABLE QUANTITIES OF CALCIUM CARBONATE.
WELL GRADED	HAVING WIDE RANGE IN GRAIN SIZES AND SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES.
POORLY GRADED	PREDOMINANTLY OF ONE GRAIN SIZE, OR HAVING A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING.

SOIL CLASSIFICATION LEGEND

N	STANDARD PENETRATION RESISTANCE IN BLOWS PER FOOT
%-200	PERCENT PASSING NO. 200 SIEVE SIZE (PERCENT FINES)
50/3"	50 BLOWS FOR 3 INCHES PENETRATION INTO SOIL
▽	GROUNDWATER LEVEL MEASURED ON DATE DRILLED
▼	GROUNDWATER LEVEL MEASURED AFTER DRILLING
γd	IN-PLACE DRY DENSITY IN PCF
Su	UNDRAINED SHEAR STRENGTH IN KSF

SILT	SILTY-GRAVEL
SAND	GRAVELLY-SAND
CLAY	GRAVELLY-CLAY
SHELL	HARD-LIMESTONE
GRAVEL	WEATHERED-LIMESTONE
CLAYEY-SAND	SHELLY-SAND
CLAYEY-SILT	SHELLY-CLAY
CLAYEY-GRAVEL	SHELLY-GRAVEL
SANDY-SILT	MUCK
SANDY-CLAY	PEAT
SANDY-GRAVEL	CONCRETE
SANDY-PEAT	ASPHALT
SILTY-SAND	CAVITY
SILTY-CLAY	

REV	DESCRIPTION OF REVISION	BY	DATE

DESIGNED BY: G. WANTLAND
DRAWN BY: W. WEBER
CHECKED BY: J. JONES
PROJECT MANAGER: G. WANTLAND
DATE: APRIL 2, 2001

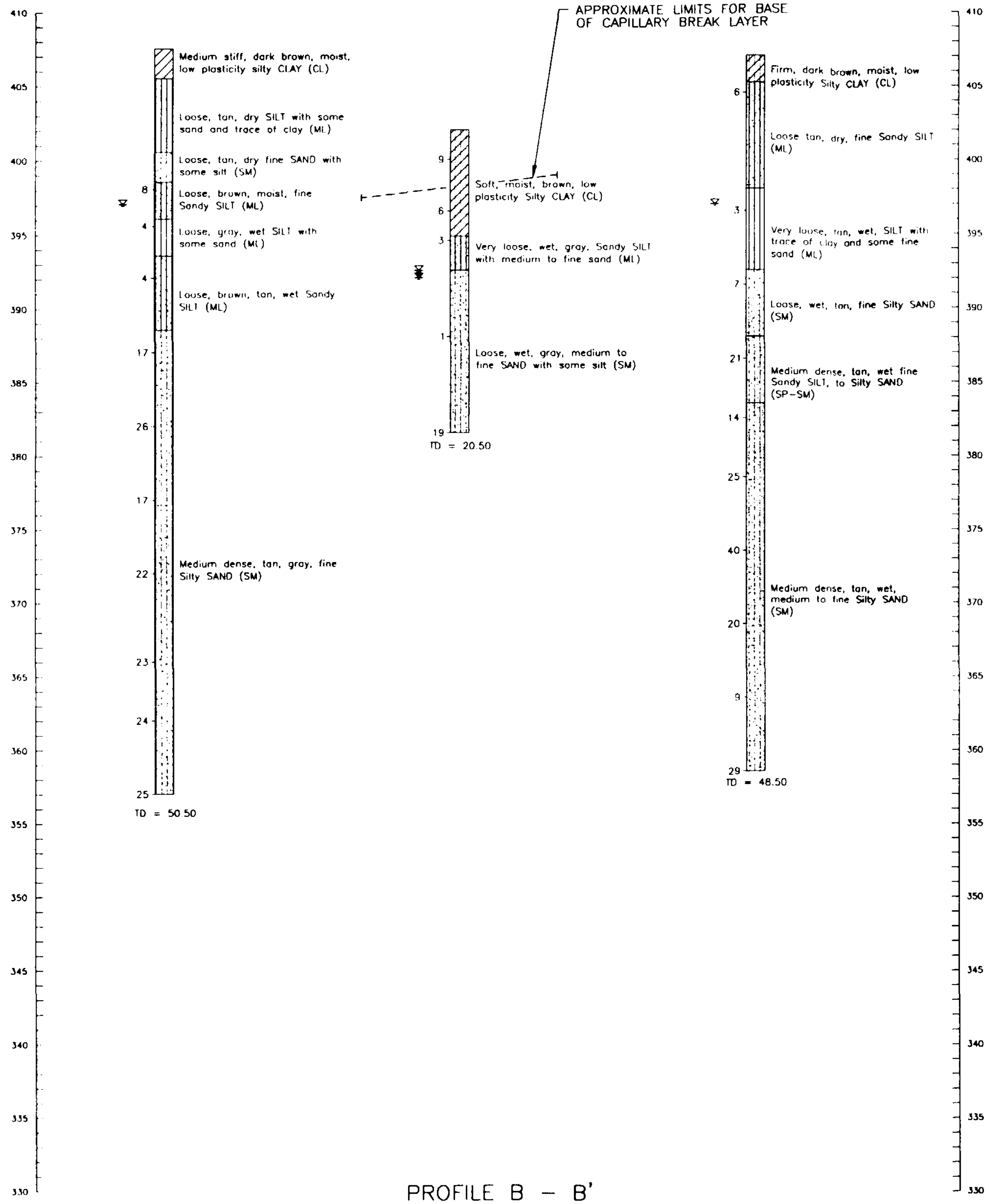
URS
URS Corporation Southern
7650 West Courtney Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

SOLUTIA INC.
SAUGET AREA 1
CAHOKIA, ILLINOIS

BORING PROFILE A - A'

PROJECT NUMBER: C100004051.00
FIGURE: **3-2**

S:\C10000\4000\4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 3-2_ BORING PROFILE NORTH-SOUTH.DWG 03/28/01 17:05



PROFILE B – B'

ENGINEERING CLASSIFICATION

I. COHESIONLESS SOILS

DESCRIPTION	BLOW COUNT "N" *
VERY LOOSE	0 TO 4
LOOSE	5 TO 10
MEDIUM DENSE	11 TO 30
DENSE	31 TO 50
VERY DENSE	OVER 50

* BLOWS PER FOOT MEASURED USING 140 POUND WEIGHT HAVING A FREE FALL OF 30 INCHES

II. COHESIVE SOILS

DESCRIPTION	UNCONFINED COMPRESSIVE STRENGTH, QU, TSF	BLOW COUNT "N"
VERY SOFT	<1/4	0 TO 2
SOFT	1/4 TO 1/2	3 TO 4
MEDIUM STIFF	1/2 TO 1	5 TO 8
STIFF	1 TO 2	9 TO 15
VERY STIFF	2 TO 4	16 TO 30
HARD	OVER 4	OVER 30

TERMS CHARACTERIZING SOIL STRUCTURE

SLICKENSIDED	HAVING INCLINED PLANES OF WEAKNESS THAT ARE SLICK AND GLOSSY IN APPEARANCE.
FISSURED	CONTAINING SHRINKAGE CRACKS, FREQUENTLY FILLED WITH FINE SAND OR SILT; USUALLY MORE OR LESS VERTICAL.
LAMINATED	COMPOSED OF THIN LAYERS OF VARYING COLOR AND TEXTURE.
INTERBEDDED	COMPOSED OF ALTERNATE LAYERS OF DIFFERENT SOIL TYPES.
CALCAREOUS	CONTAINING APPRECIABLE QUANTITIES OF CALCIUM CARBONATE.
WELL GRADED	HAVING WIDE RANGE IN GRAIN SIZES AND SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES.
POORLY GRADED	PREDOMINANTLY OF ONE GRAIN SIZE, OR HAVING A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING.

SOIL CLASSIFICATION LEGEND

N	STANDARD PENETRATION RESISTANCE IN BLOWS PER FOOT
%-200	PERCENT PASSING NO. 200 SIEVE SIZE (PERCENT FINES)
50/3"	50 BLOWS FOR 3 INCHES PENETRATION INTO SOIL
∇	GROUNDWATER LEVEL MEASURED ON DATE DRILLED
▼	GROUNDWATER LEVEL MEASURED AFTER DRILLING
γd	IN-PLACE DRY DENSITY IN PCF
Su	UNDRAINED SHEAR STRENGTH IN KSF

REV | DESCRIPTION OF REVISION | BY | DATE

DESIGNED BY: G. WANTLAND
DRAWN BY: W. WEBER
CHECKED BY: J. JONES
PROJECT MANAGER: G. WANTLAND
DATE: APRIL 2, 2001

URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

SOLUTIA INC.
SAUGET AREA 1
CAHOKIA, ILLINOIS

BORING PROFILE B - B'

PROJECT NUMBER C100004051.00

FIGURE 3-3

ILLINOIS STATE GEOLOGICAL SURVEY

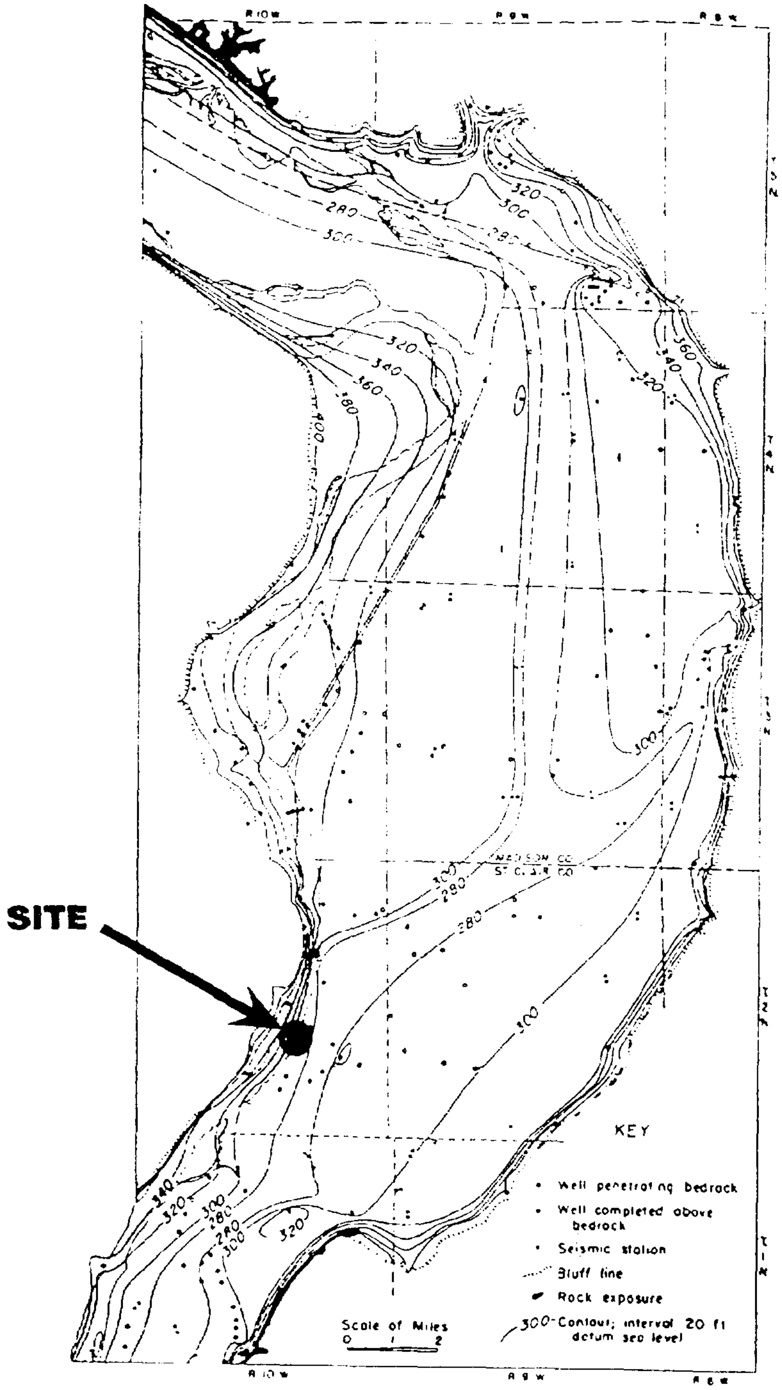
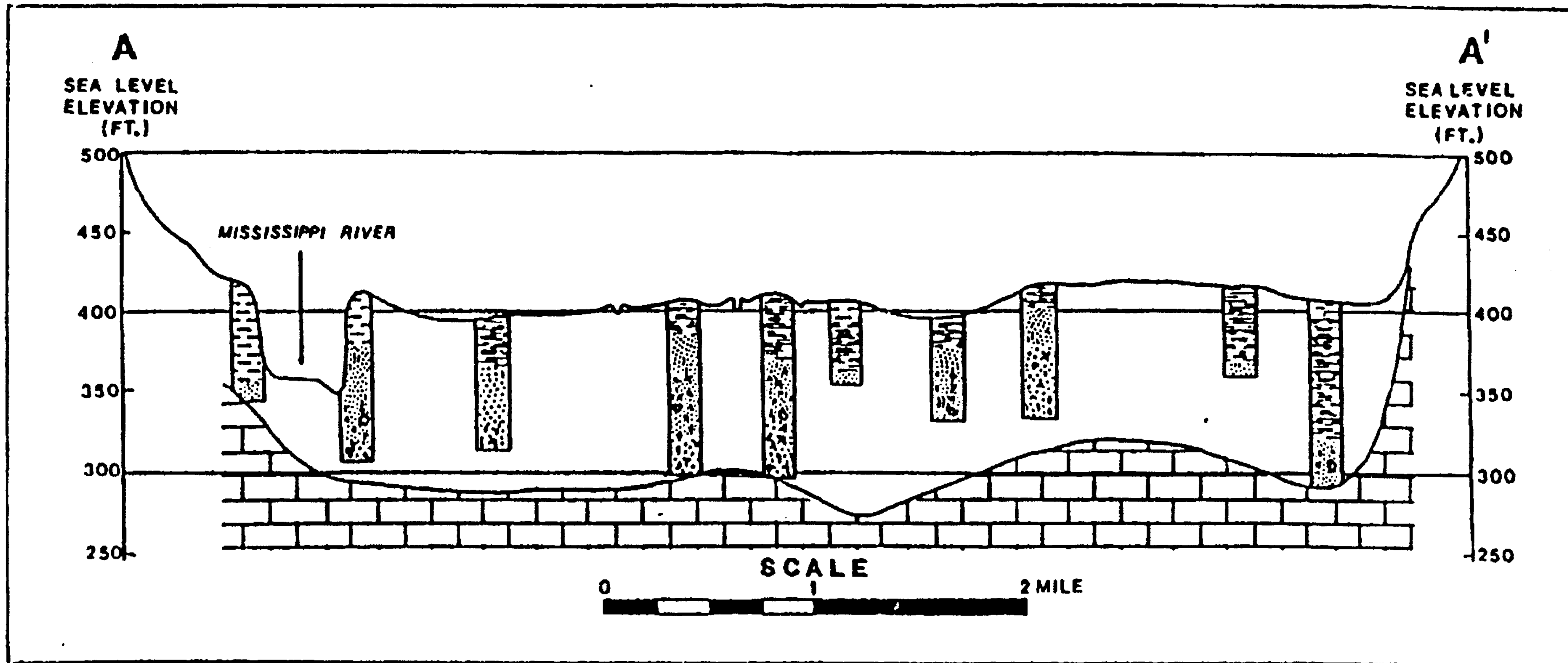


Fig. 2.—Bedrock surface map of the East St. Louis area, Illinois

REFERENCE: Map taken from Groundwater Geology of the East St. Louis Area, Illinois, R. Bergstrom and T Walker, 1956.

PREPARED FOR: SOLUTIA	Drawn: W. WEBER	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE 3-4
URS JOB NUMBER: C100004051.00	Design: GARY WANTLAND		
URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Checked: GARY WANTLAND	DRAWING TITLE **BEDROCK ELEVATION MAP**	
	Date: APRIL 2, 2001		

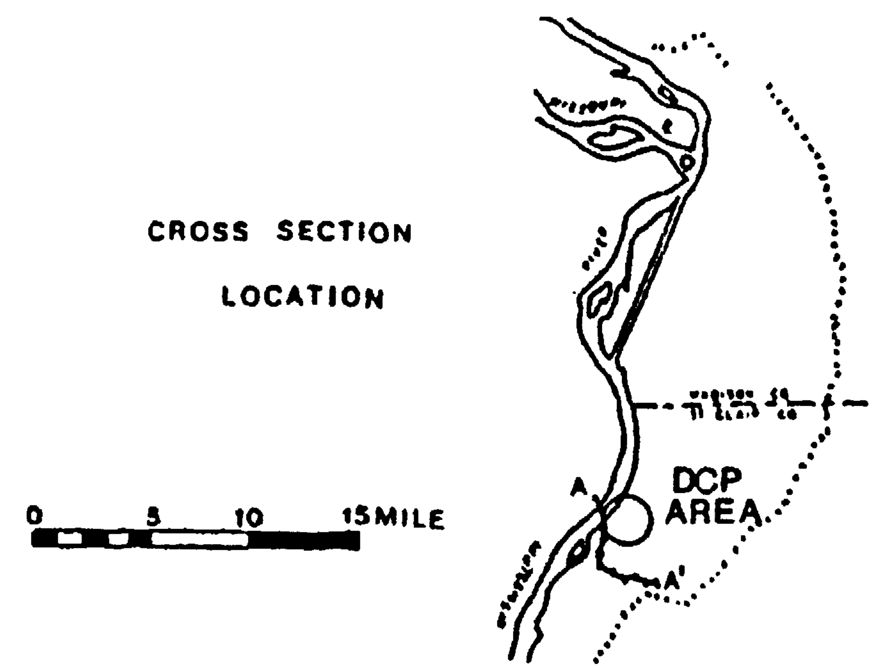
S:\C10000\4000\4051.00\FINAL DESIGN REPORT\FIGURES\FIG3-4.DWG 04/25/01 09:31



SOURCE: Bergstrom, 1956

LEGEND

- CLAY
- SILT
- FINE SAND
- MEDIUM SAND
- GRAVEL
- BEDROCK SURFACE



REV	DESCRIPTION OF REVISION	BY	DATE

PREPARED FOR: SOLUTIA
URS JOB NUMBER: C100004051.00

URS
URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

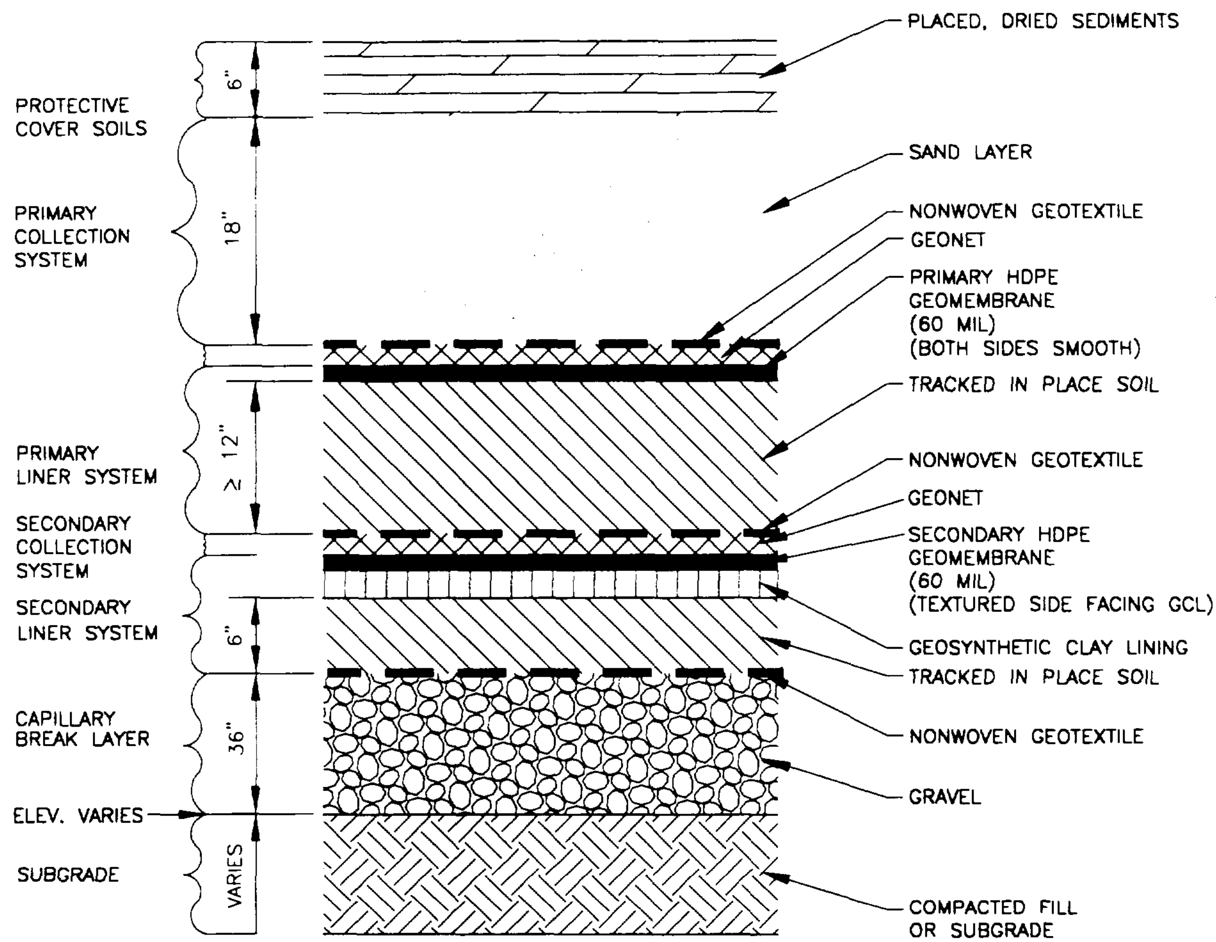
Drawn: W. WEBER
Design: GARY WANTLAND
Checked: GARY WANTLAND
Date: APRIL 2, 2001

PROJECT NAME
SOLUTIA INC.
SAUGET AREA 1
CAHOKIA, ILLINOIS

DRAWING TITLE
GEOLOGIC
CROSS SECTION

FIGURE
3-5

S:\0000\4000\4051.00\FINAL DESIGN REPORT\FIGURES\FIGL_3-5.DWG 04/24/01 11:19

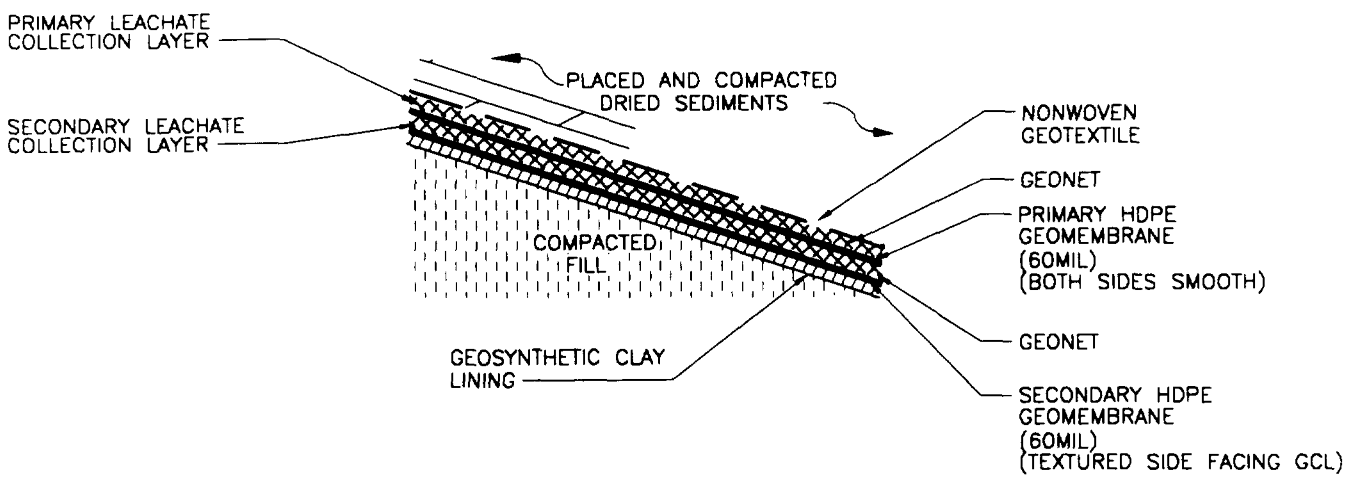


NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA	Drawn: W. WEBER	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE
URS JOB NUMBER: C100004051.00	Design: GARY WANTLAND		
URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Checked: GARY WANTLAND	DRAWING TITLE **BOTTOM LINER SYSTEM DETAIL**	4-1
	Date: APRIL 2, 2001		



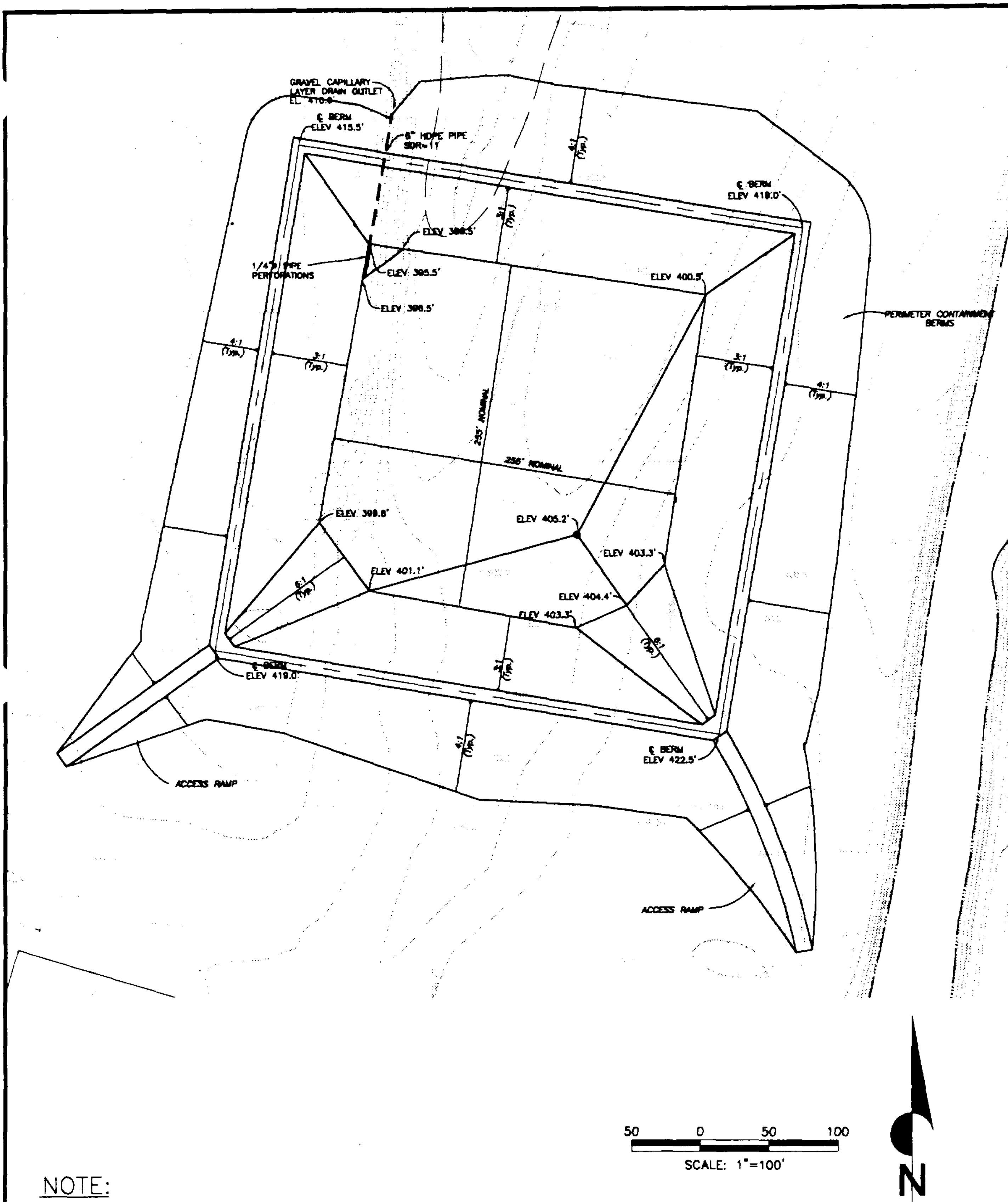
NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA	Drawn: W. WEBER	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE
URS JOB NUMBER: C100004051.00	Design: GARY WANTLAND		
URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Checked: GARY WANTLAND	DRAWING TITLE **SIDE SLOPE LINER SYSTEM DETAIL**	4-2
	Date: APRIL 2, 2001		

S:\C10000\4000\FINAL DESIGN REPORT\FIGURES\FIGURE 4-2.DWG 03/28/01 16:21

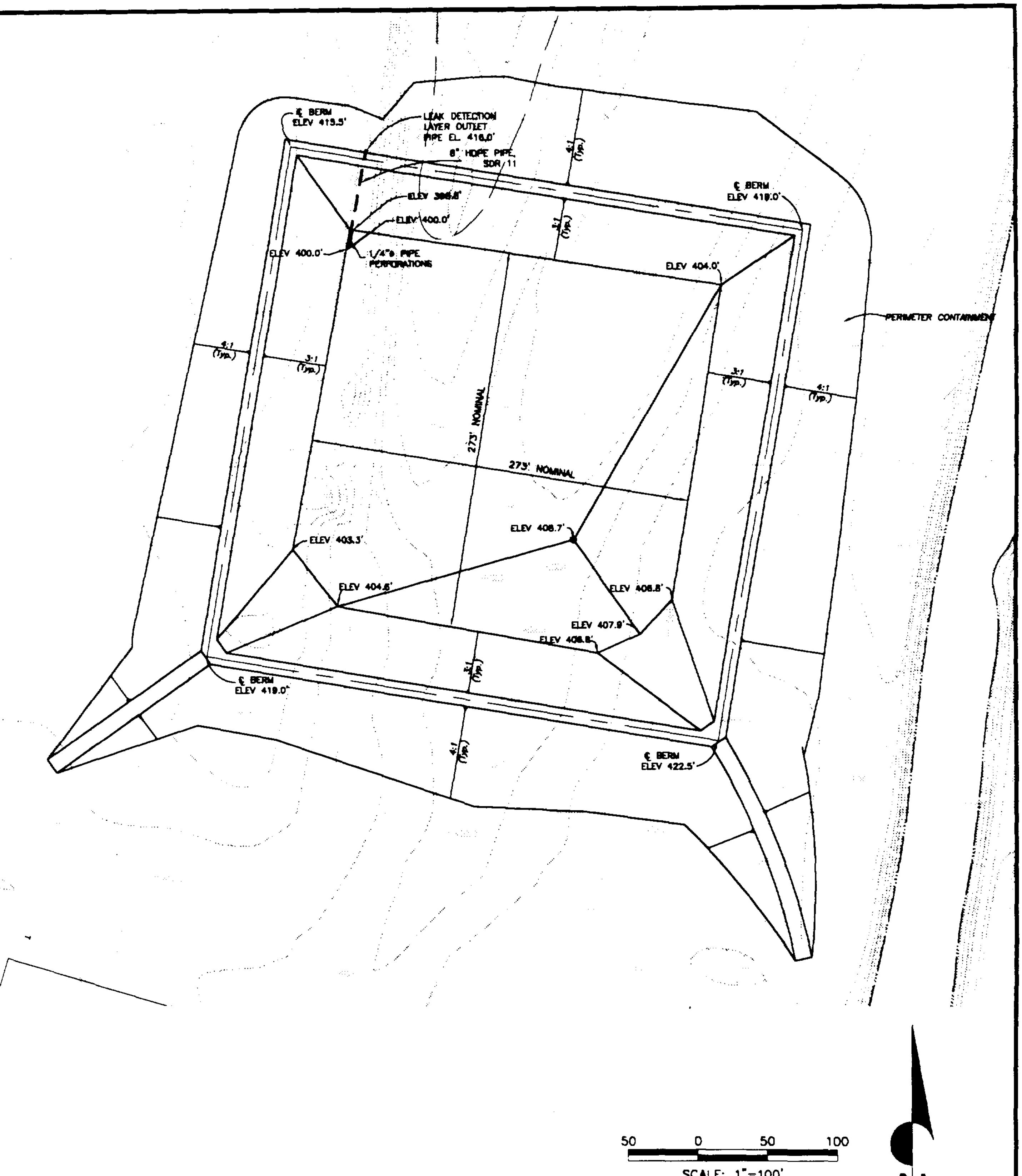


NOTE:

1. NOT FOR CONSTRUCTION.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC.** **SAUGET AREA 1** DRAWING TITLE **SITE PREPARATION PLAN**	FIGURE 4-3

S:\C10000\400C O\FINAL DESIGN REPORT\FIGURES\FIGURE 4-3_SITE PREP PLAN.DWG 03/28/01 15:30

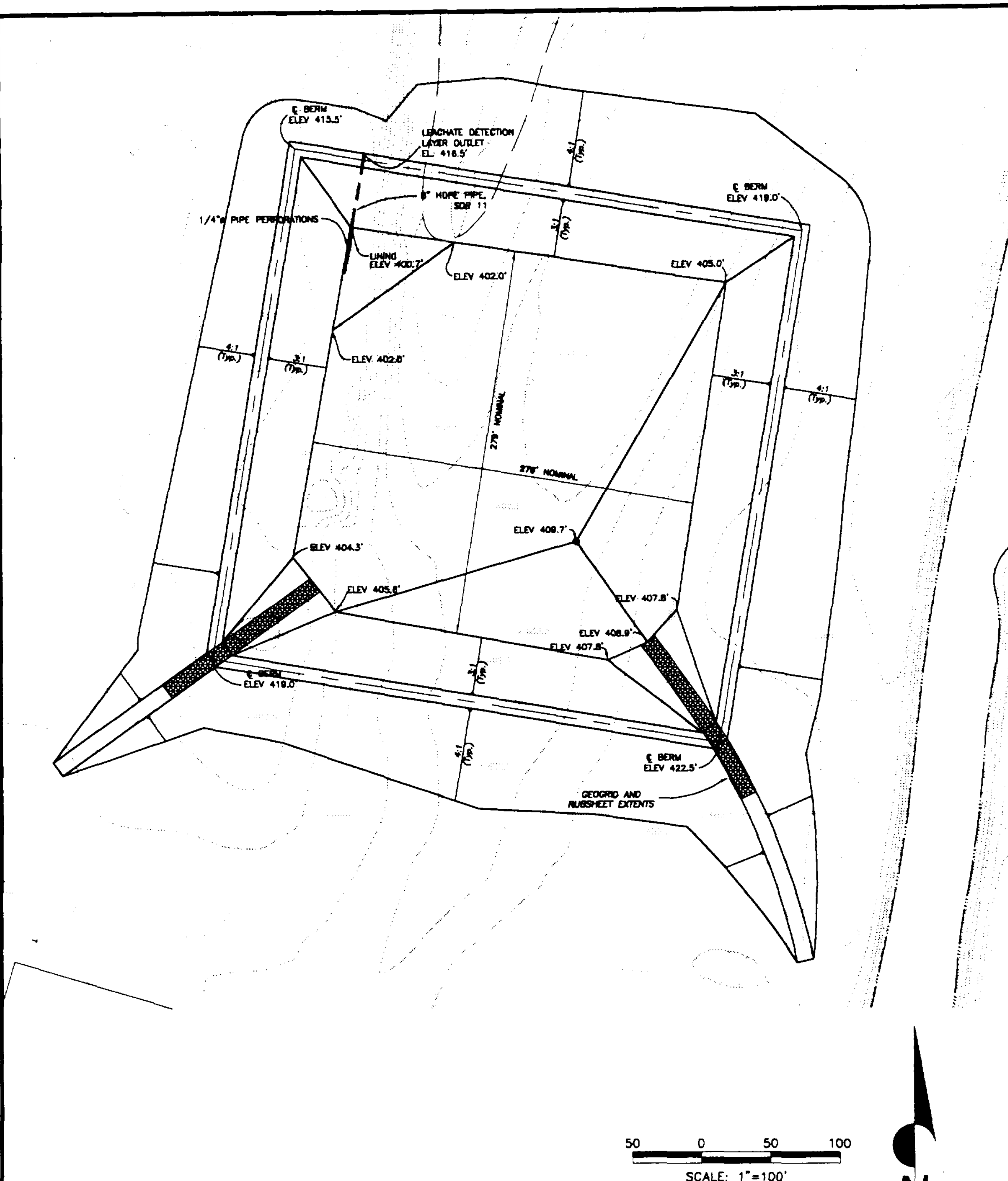


NOTE:

1. NOT FOR CONSTRUCTION.

S:\C10000\400C\FINAL DESIGN REPORT\FIGURES\FIGURE 4-4_SEC GEOMEM LAYOUT.DWG 03/28/01 15:39

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME: SOLUTIA INC. SAUGET AREA 1 DRAWING TITLE: SECONDARY GEOMEMBRANE LAYOUT	FIGURE 4-4

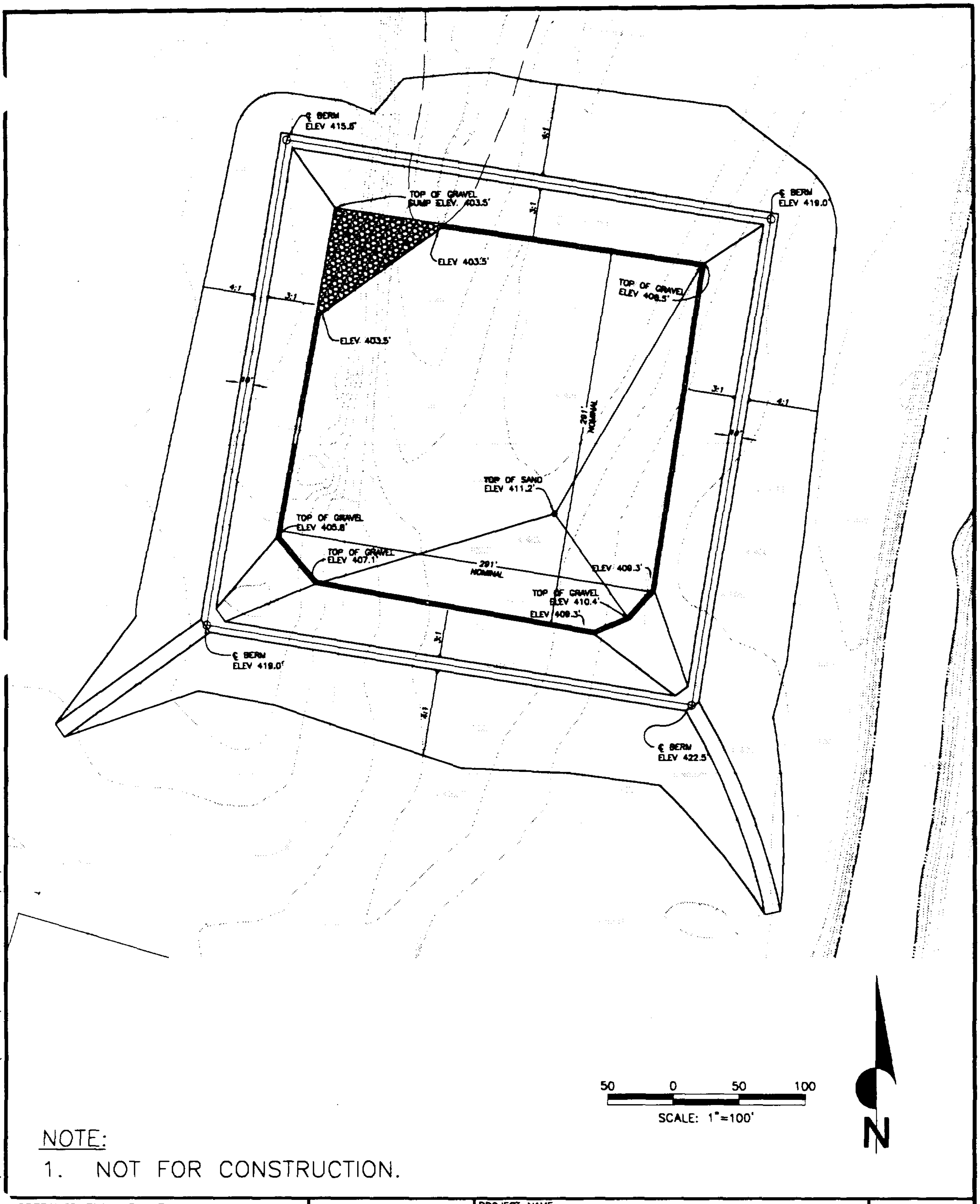


NOTE:

1. NOT FOR CONSTRUCTION.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC.** **SAUGET AREA 1** DRAWING TITLE **PRIMARY GEOMEMBRANE LAYOUT**	FIGURE 4-5

S:\C10000\4000\4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 4-5_PRI GEOMEM LAYOUT.DWG 03/28/01 15:46



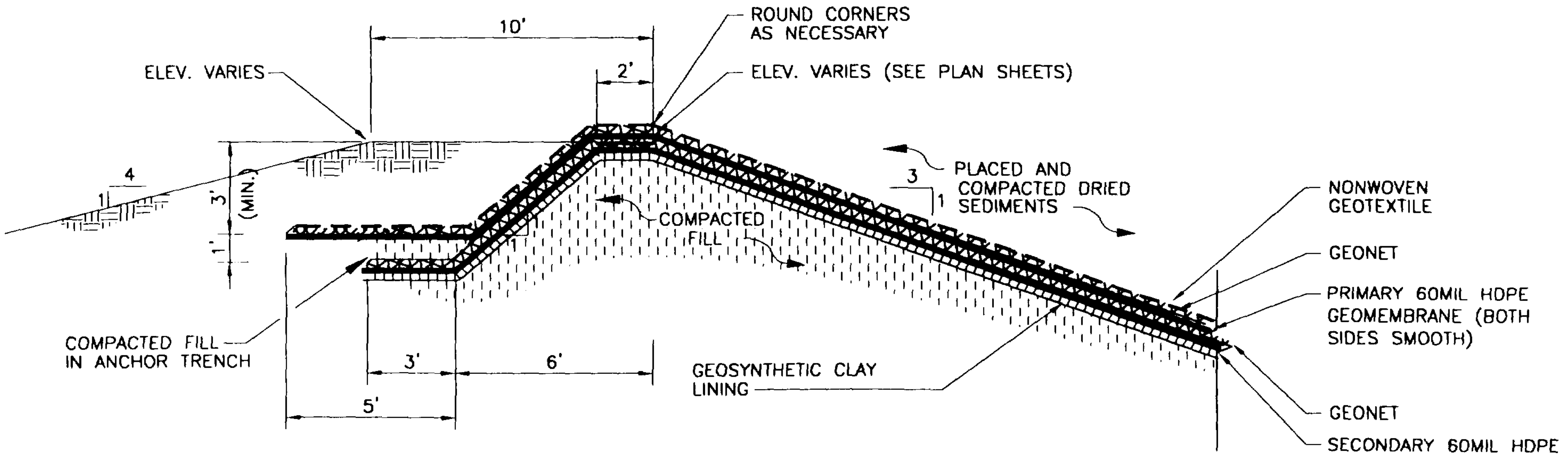
NOTE:

1. NOT FOR CONSTRUCTION.

O:\FINAL DESIGN REPORT\FIGURES\FIGURE 4-6.DWG 03/29/01 09:30

S:\C10000\400C

PREPARED FOR: SOLUTIA	Drawn: W. WEBER	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE
URS JOB NUMBER: C100004051.00	Design: GARY WANTLAND		
URS — URS Corporation Southern, 7650 West Courtney Campbell Causeway, Tampa, FL 33607-1462, No. 00000002	Checked: GARY WANTLAND	DRAWING TITLE TOP OF PRIMARY COLLECTION SYSTEM PLAN	4-6
	Date: APRIL 2, 2001		



PRIMARY LINER SYSTEM ANCHOR DETAIL

D
C1.4 | C1.6

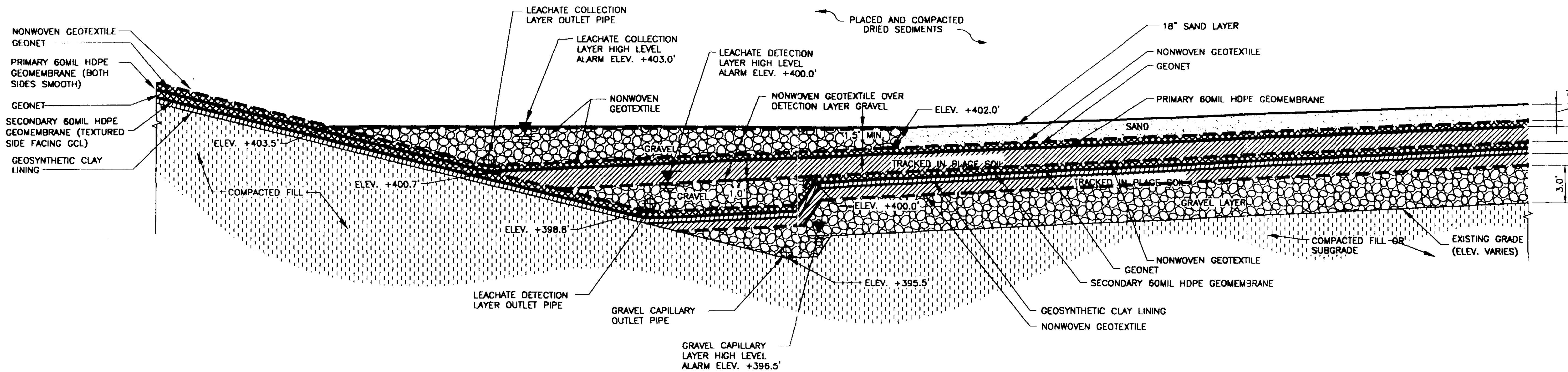
APPROX. SCALE: 1" = 5'

NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS — URS Corporation Southern, 7650 West Courtney Campbell Causeway, Tampa, FL 33607-1462, No. 00000002	Drawn: DRH Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	DRAWING TITLE **PRIMARY LINER SYSTEM ANCHOR DETAIL**	FIGURE 4-7



NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

REV	DESCRIPTION OF REVISION	BY	DATE

DESIGNED BY: M. BRUNOARD
DRAWN BY: G. BRADFORD
CHECKED BY: C. WANTLAND
PROJECT MANAGER: C. WANTLAND
DATE: APRIL 2, 2001

URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

SOLUTIA INC.
SAUGET AREA 1
CAHOKIA, ILLINOIS

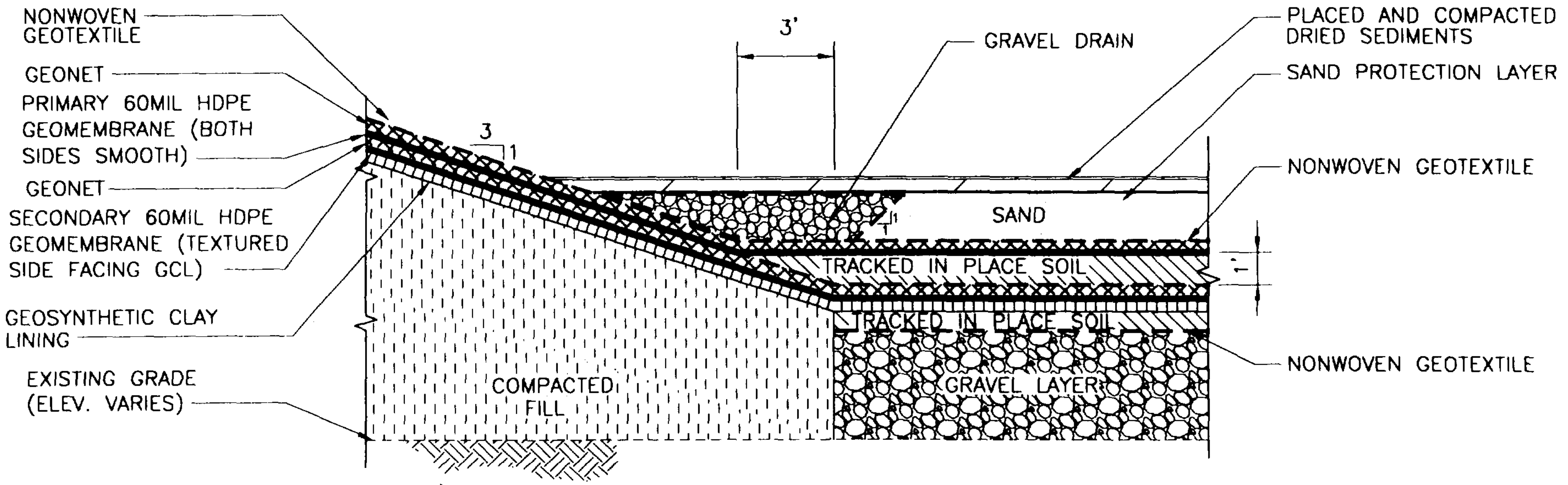
COLLECTION SUMP SECTION

PROJECT NUMBER C100004051.00

FIGURE 4-8

S:\C10000\4000.00\FINAL DESIGN REPORT\FIGURES\FIGURE 4-8.DWG 03/29/01

S:\C10000' — \4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 4-9.DWG 03/29/ 09:39



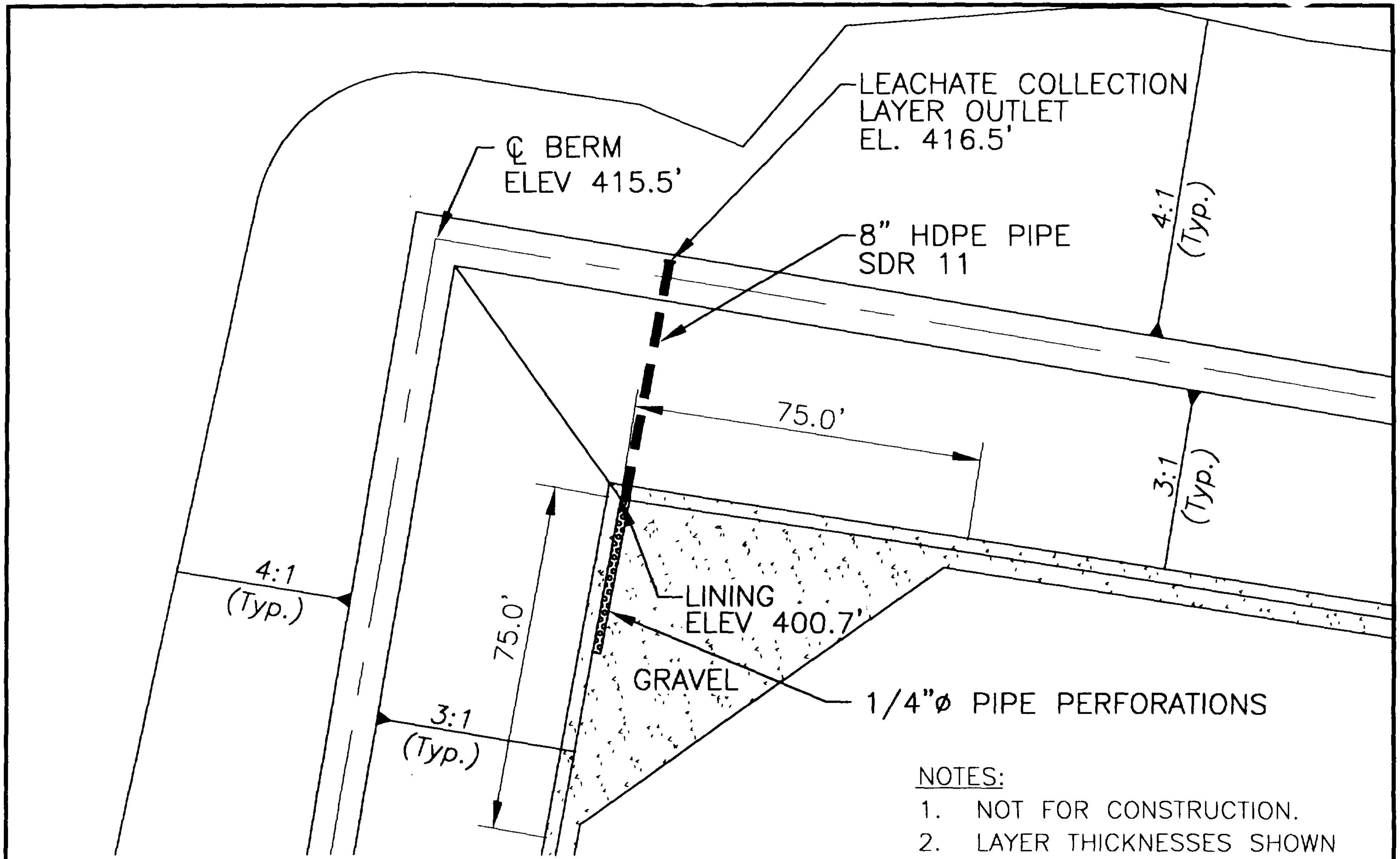
NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: DRH Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC.** **SAUGET AREA 1**	DRAWING TITLE **GRAVEL DRAIN DETAIL**	FIGURE 4-9

S:\C10000)\4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 4-10.DWG 03/29 11:46

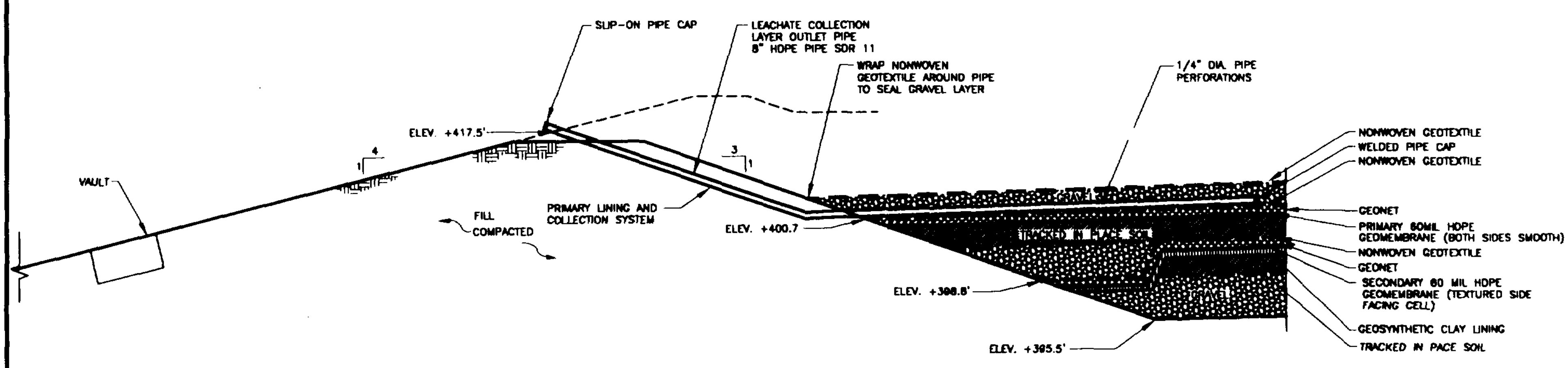


NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: DRH Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC. SAUGET AREA 1**	DRAWING TITLE **LEACHATE COLLECTION LAYER OUTLET PIPE PLAN**	FIGURE 4-10



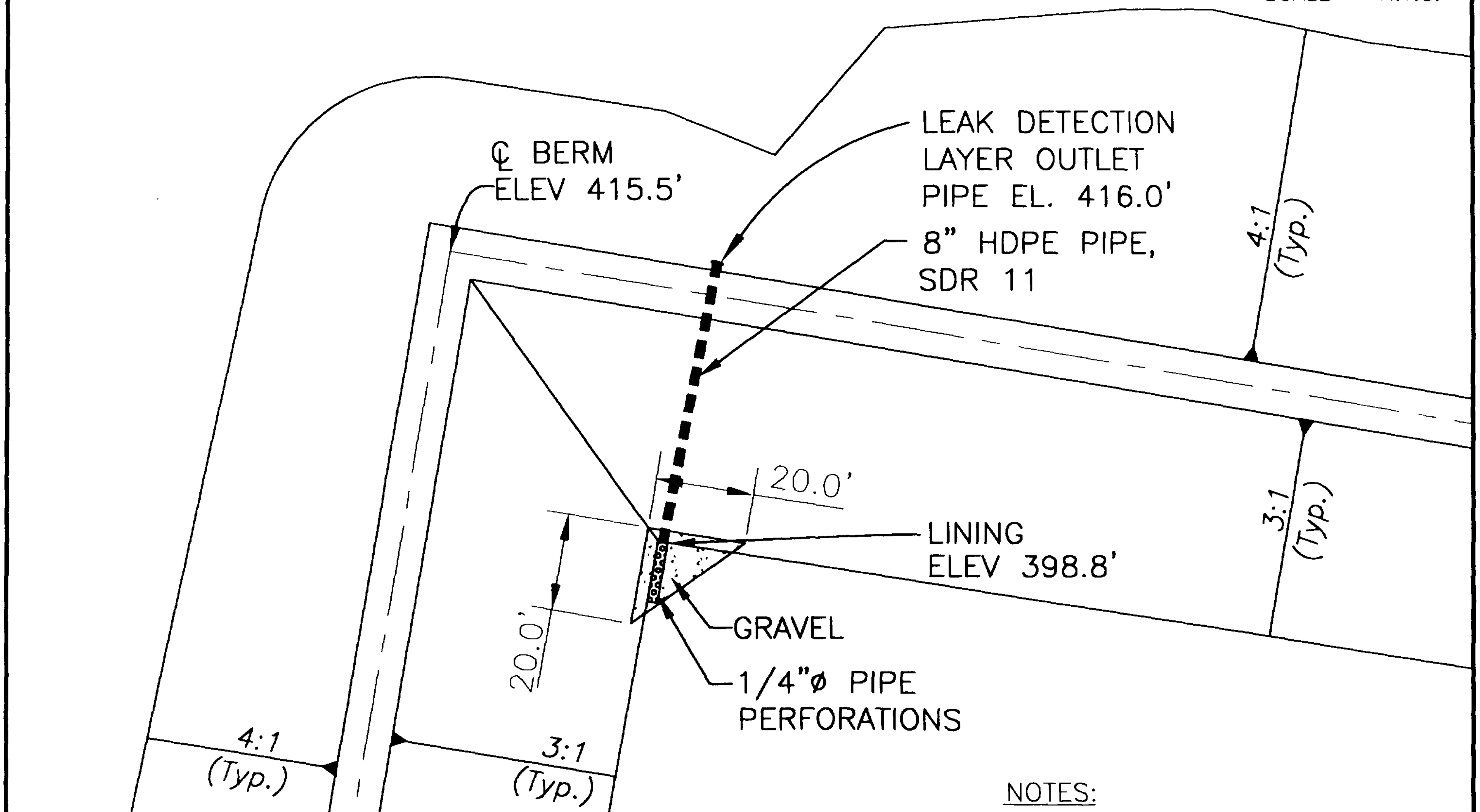
NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS — URS Corporation Southern, 7650 West Courtney Campbell Causeway, Tampa, FL 33607-1462, No. 00000002	Drawn: DRH Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC. SAUGET AREA 1**	DRAWING TITLE **PRIMARY LEACHATE COLLECTION LAYER OUTLET PIPE SECTION**	FIGURE 4-11

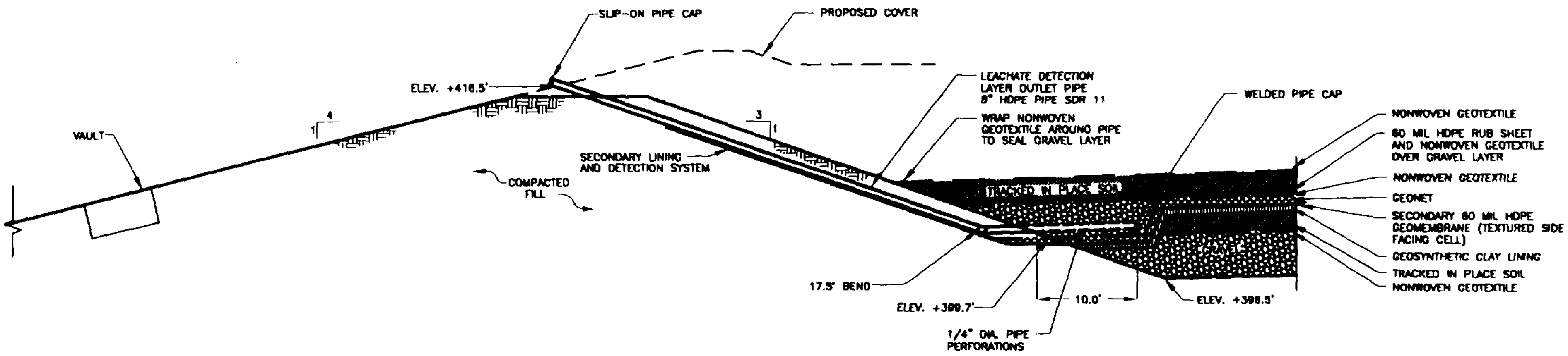
SCALE = N.T.S.



NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: DRH Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC.** **SAUGET AREA 1**	DRAWING TITLE **LEACHATE DETECTION LAYER OUTLET PIPE PLAN**	FIGURE 4-12



NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA
URS JOB NUMBER: C100004051.00

URS
URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

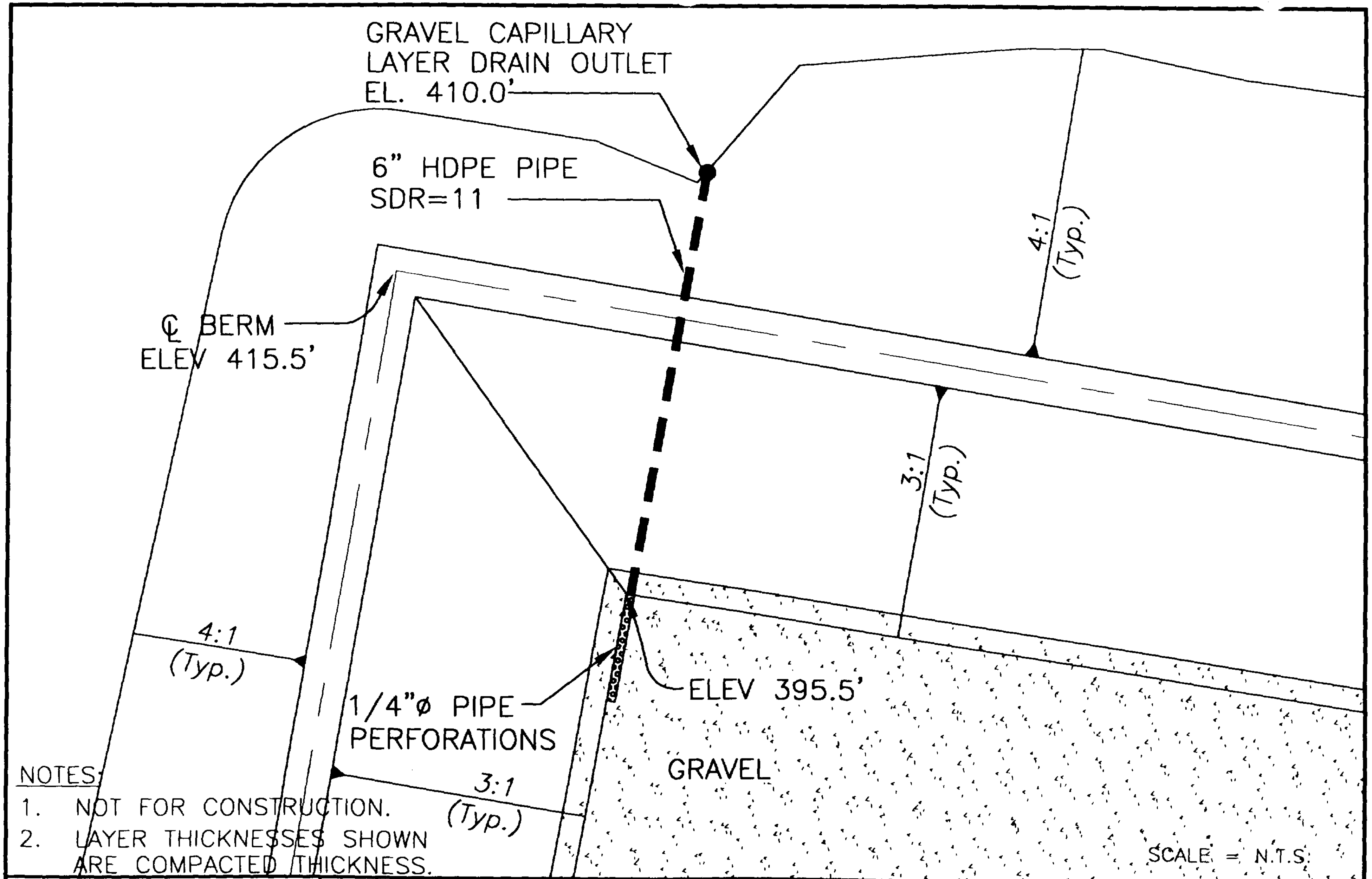
Drawn: DRH
Design: GARY WANTLAND
Checked: GARY WANTLAND
Date: APRIL 2, 2001

PROJECT NAME
SOLUTIA INC.
SAUGET AREA 1

DRAWING TITLE
SECONDARY LEACHATE DETECTION LAYER OUTLET PIPE SECTION

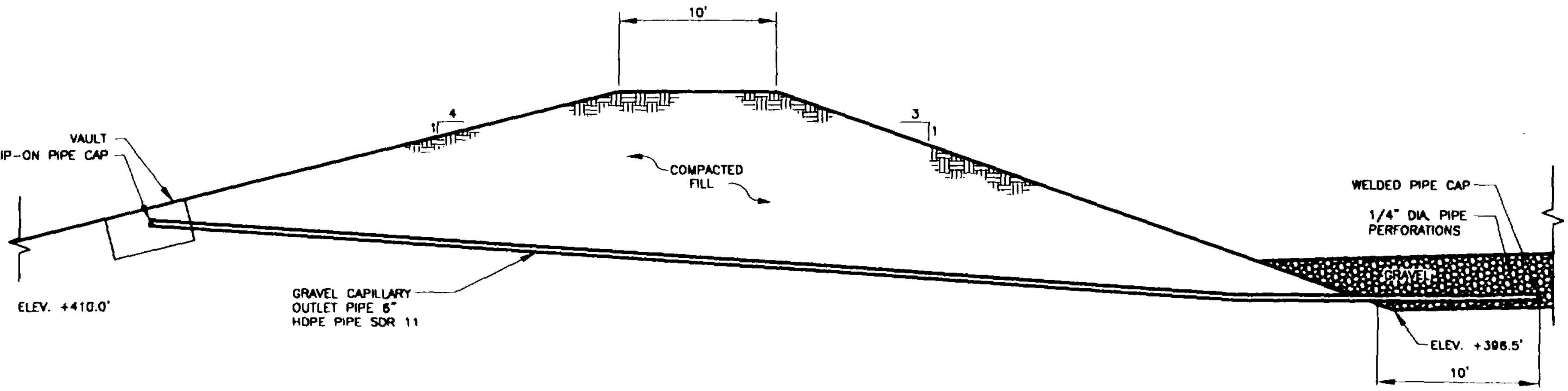
FIGURE 4-13

S:\C10000' ~ /\4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 4-14.DWG 03/29/ 11:47



NOTES:
1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: DRH Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC.** **SAUGET AREA 1**	DRAWING TITLE **GRAVEL CAPILLARY LAYER DRAIN OUTLET PLAN**	FIGURE 4-14

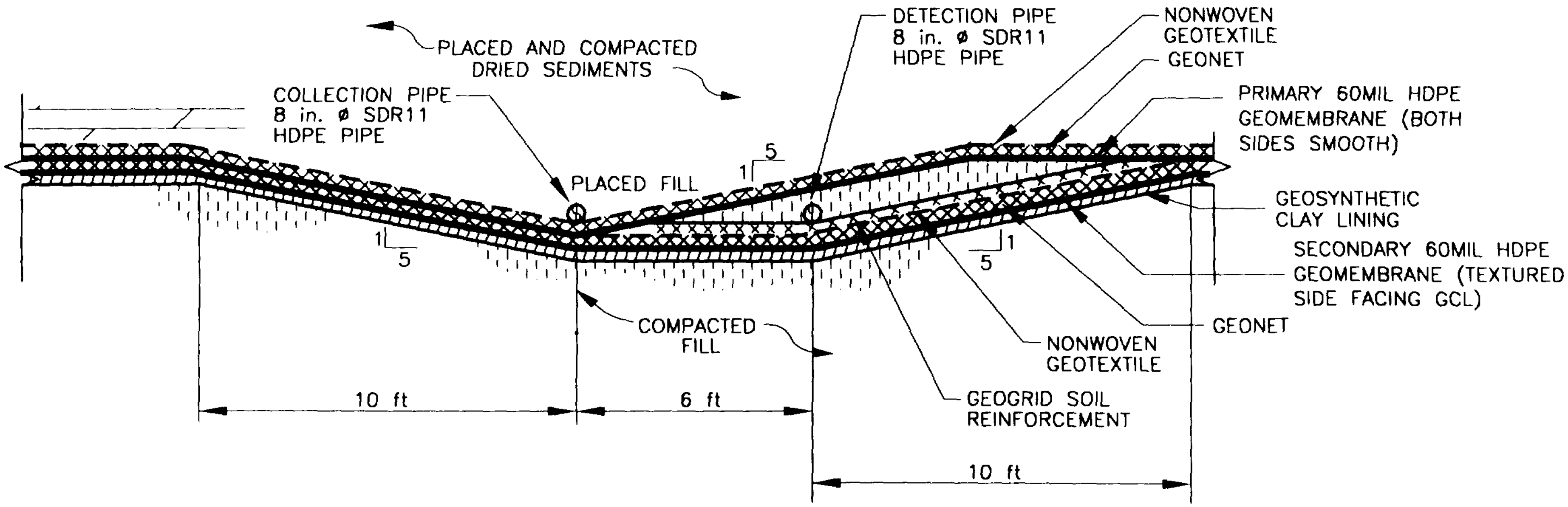


NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00	Drawn: DRH	PROJECT NAME	DRAWING TITLE	FIGURE
URS — URS Corporation Southern, 7650 West Courtney Campbell Causeway, Tampa, FL 33607-1462, No. 00000002	Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	SOLUTIA INC. SAUGET AREA 1	**GRAVEL LAYER CAPILLARY OUTLET PIPE SECTION**	4-15



NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA
URS JOB NUMBER: C100004051.00

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Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

Drawn: DRH
Design: GARY WANTLAND
Checked: GARY WANTLAND
Date: APRIL 2, 2001

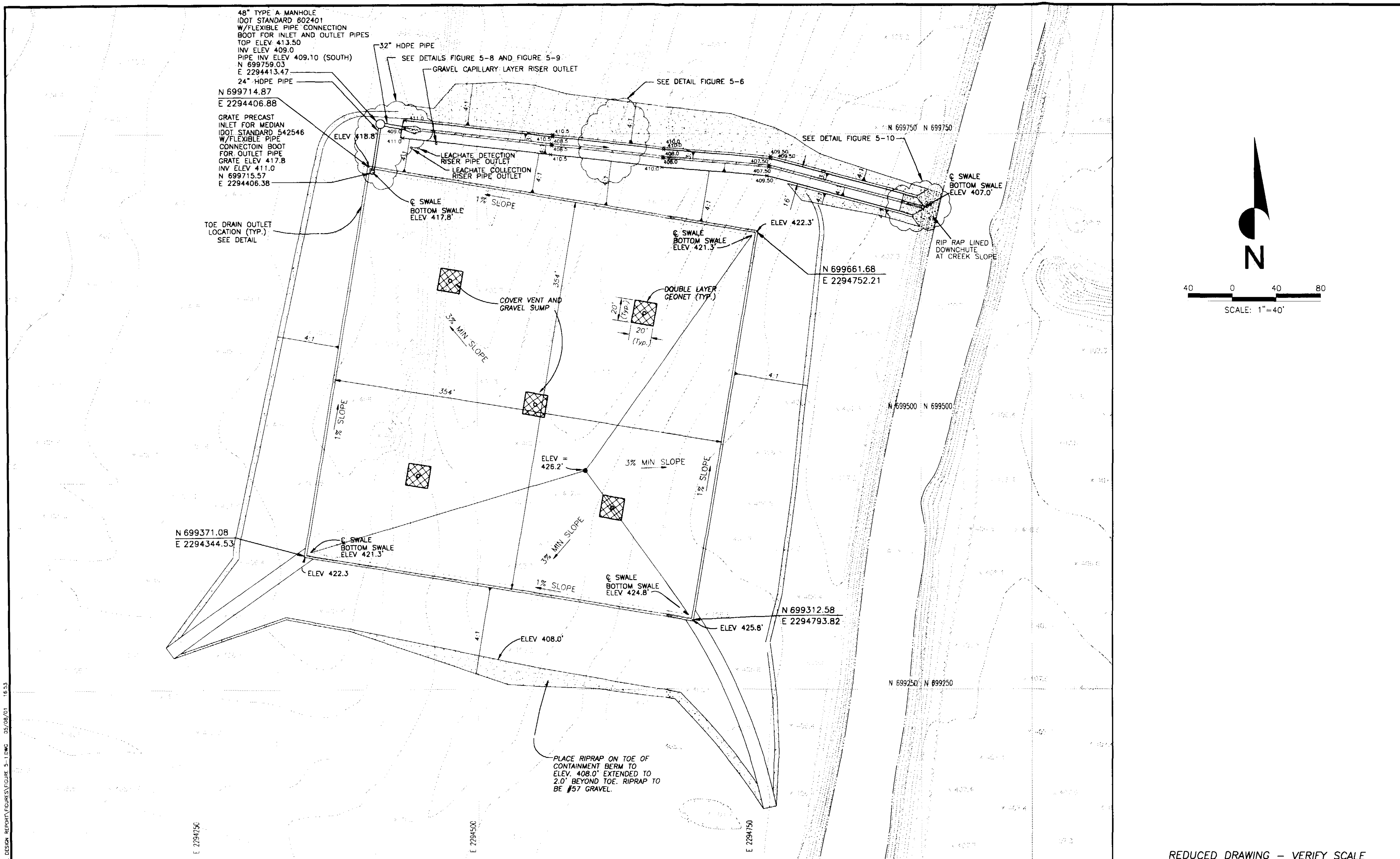
PROJECT NAME

SOLUTIA INC.
SAUGET AREA I

DRAWING TITLE

LEACHATE COLLECTION LAYER OUTLET PIPE SECTION

FIGURE 4-16



REDUCED DRAWING – VERIFY SCALE

REV	DESCRIPTION OF REVISION	BY	DATE

DESIGNED BY: M. BRUNGARD
DRAWN BY: G. BRADFORD
CHECKED BY: G. WANTLAND
PROJECT MANAGER: G. WANTLAND
DATE: APRIL 2, 2001

URS

URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

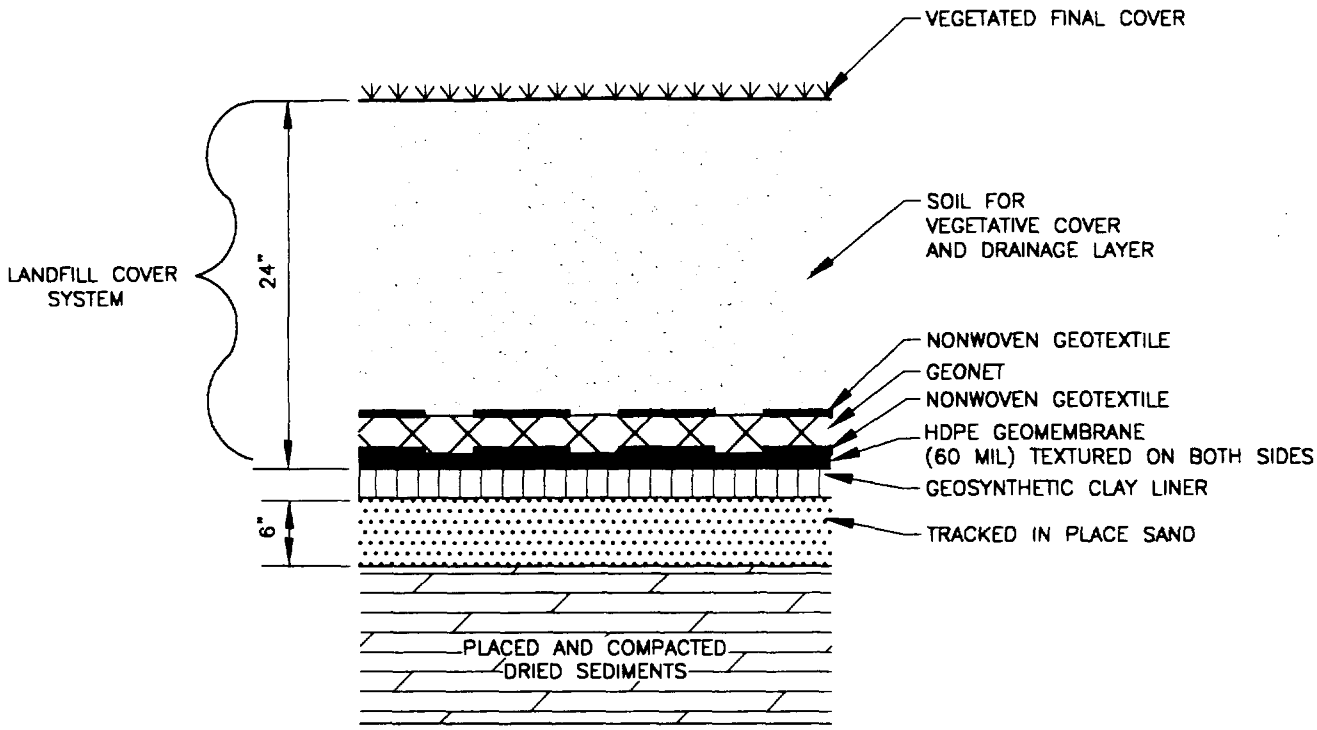
SOLUTIA INC.
SAUGET AREA 1
CAHOKIA, ILLINOIS

COVER SYSTEM PLAN

PROJECT NUMBER: C100004051.00

FIGURE: 5-1

S:\C10000\4000\4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 5-1.DWG 05/08/01 16:53



S:\C10000\400G\FINAL DESIGN REPORT\FIGURES\FIGURE 5-2_COVER SYS DETAIL.DWG 03/27/01 16:14

PREPARED FOR: SOLUTIA
URS JOB NUMBER: C100004051.00

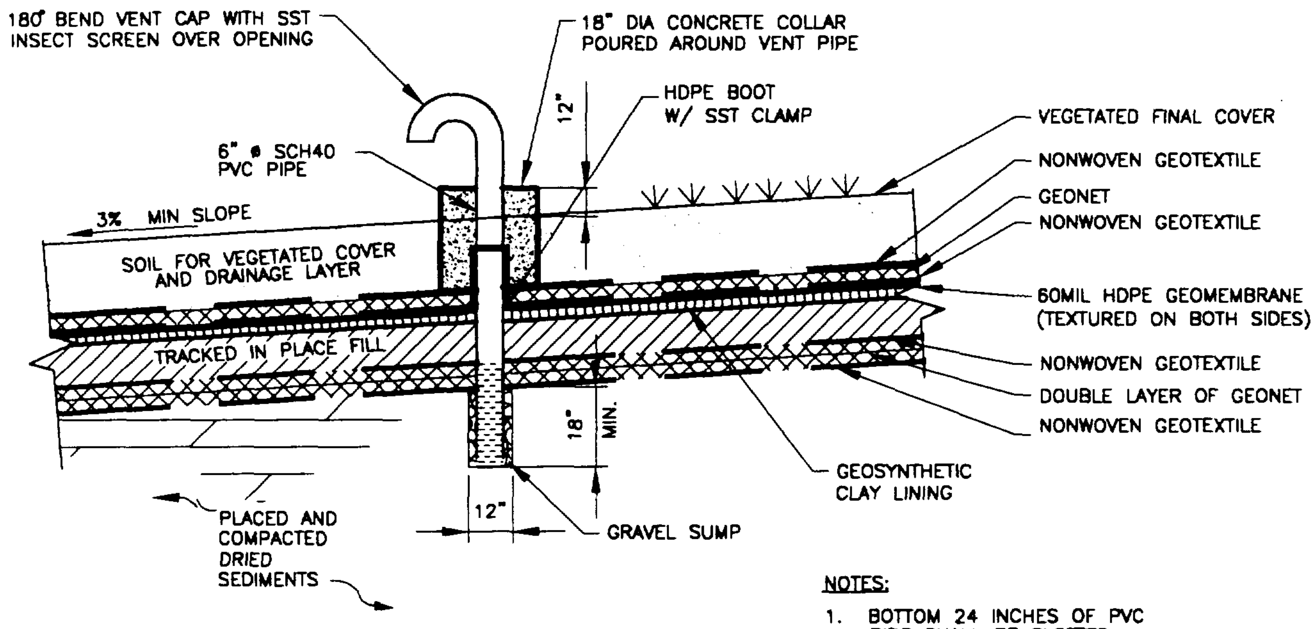
URS
URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

Drawn: W. WEBER
Design: GARY WANTLAND
Checked: GARY WANTLAND
Date: APRIL 2, 2001

PROJECT NAME
SOLUTIA INC.
SAUGET AREA 1

DRAWING TITLE
COVER SYSTEM DETAIL

FIGURE
5-2

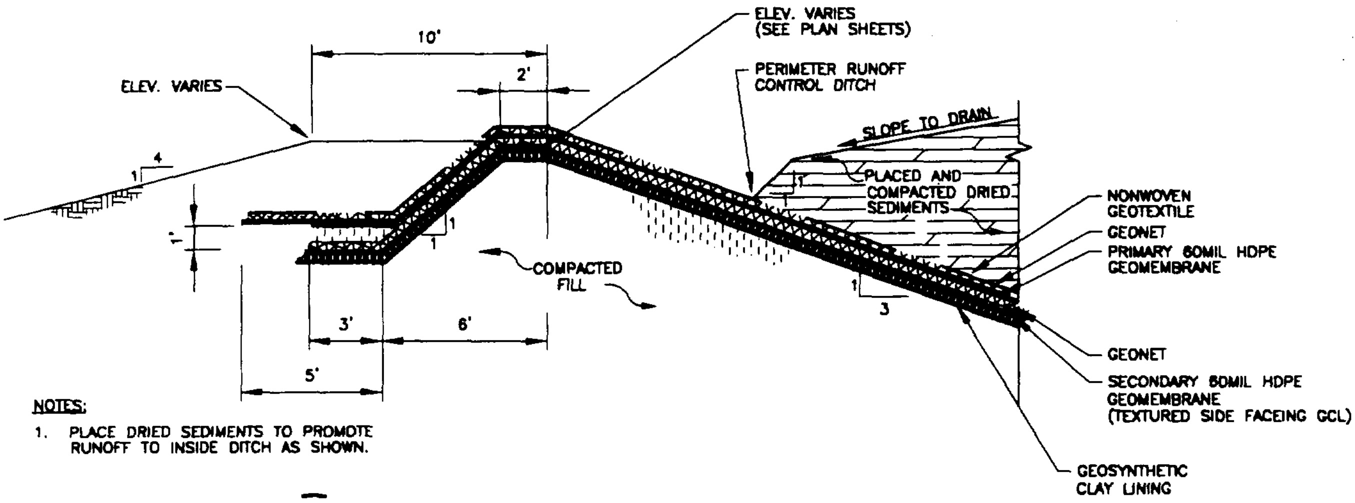


NOTES:

1. BOTTOM 24 INCHES OF PVC PIPE SHALL BE SLOTTED.
2. DOUBLE LAYER OF GEONET FOR VENT SHALL BE 20FT X 20FT IN PLAN.

S:\C10000\4000\JO\FINAL DESIGN REPORT\FIGURES\FIGURE 5-3.DWG 03/29/01 11:18

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1 DRAWING TITLE TYPICAL COVER VENT	FIGURE 5-3



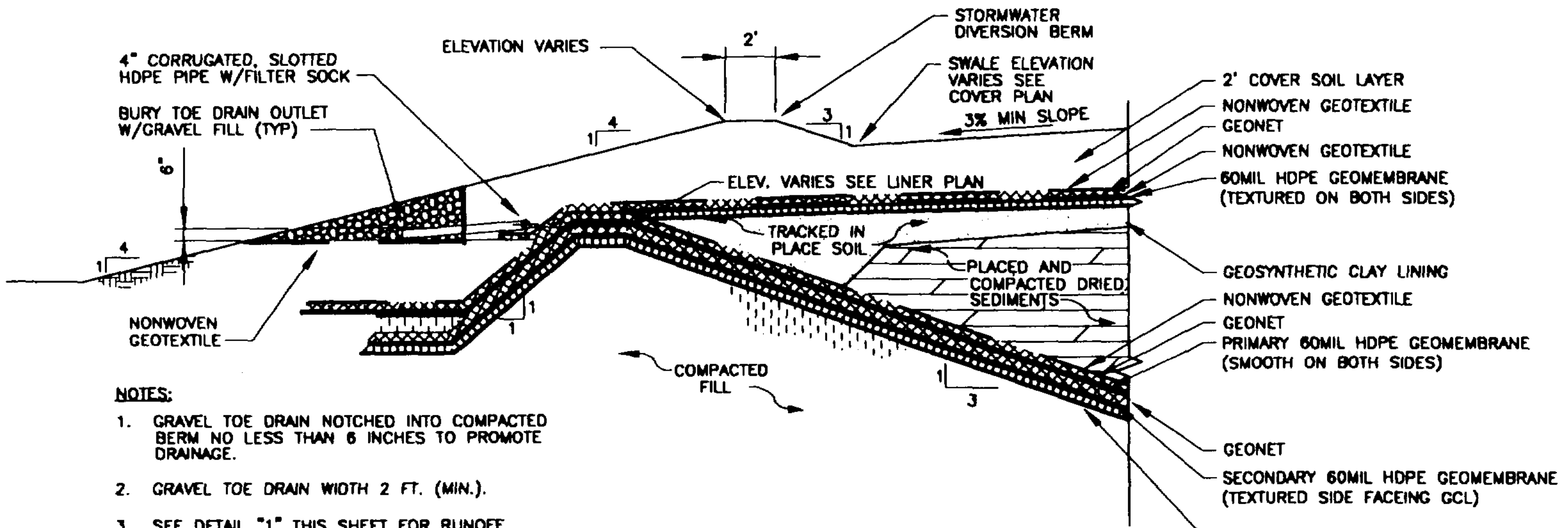
NOTES:

1. PLACE DRIED SEDIMENTS TO PROMOTE RUNOFF TO INSIDE DITCH AS SHOWN.

S:\C10000\4000\FINAL DESIGN REPORT\FIGURES\FIGURE 5-4.DWG 03/29/01 11:27

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1 DRAWING TITLE RUNOFF CONTROL BERM DETAIL	FIGURE 5-4

S:\C10000\400 ..00\FINAL DESIGN REPORT\FIGURES\FIGURE 5-5.DWG 03/29/01 11:24



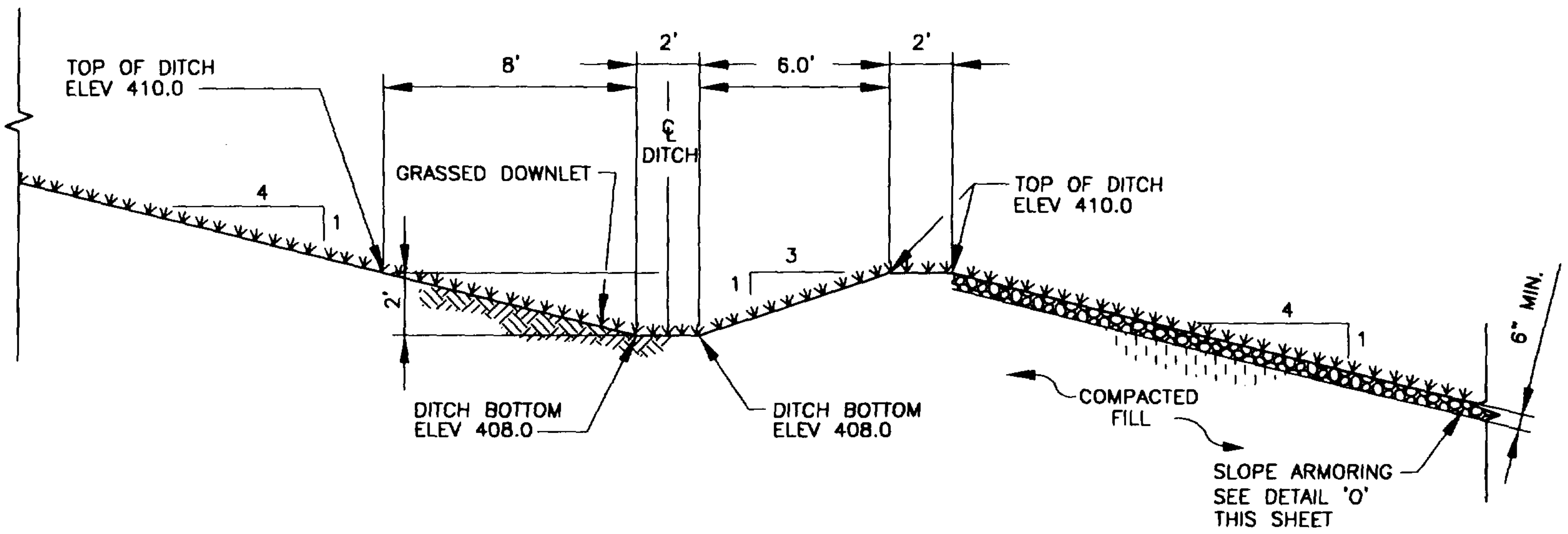
NOTES:

1. GRAVEL TOE DRAIN NOTCHED INTO COMPACTED BERM NO LESS THAN 6 INCHES TO PROMOTE DRAINAGE.
2. GRAVEL TOE DRAIN WIDTH 2 FT. (MIN.).
3. SEE DETAIL "1" THIS SHEET FOR RUNOFF CONTROL DURING PLACEMENT OF DRIED SEDIMENTS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS — URS Corporation Southern, 7650 West Courtney Campbell Causeway, Tampa, FL 33607-1462, No. 00000002	Drawn: W. WEBBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	DRAWING TITLE FINAL COVER DETAIL	FIGURE 5-5

S:\C10000\400.. .1.00\FINAL DESIGN REPORT\FIGURES\FIGURE 5-6.DWG 03/27/01 16:26



NOTE:

SLOPE ARMORING TO BEGIN AT ELEV 410.0 ALONG DOWNSHUTE.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA

URS JOB NUMBER: C100004051.00

URS

URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

Drawn: W. WEBBER

Design: GARY WANTLAND

Checked: GARY WANTLAND

Date: APRIL 2, 2001

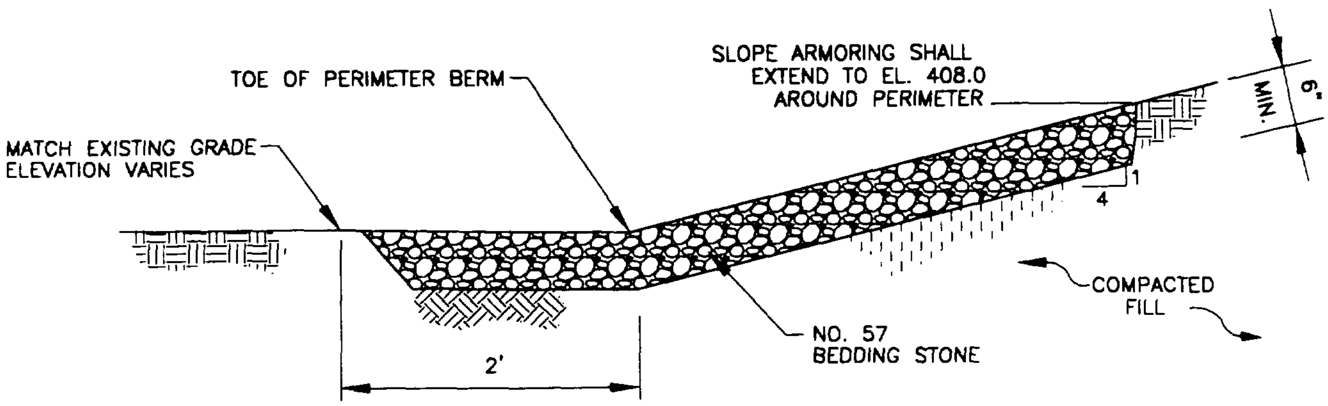
PROJECT NAME

SOLUTIA INC.
SAUGET AREA 1

DRAWING TITLE

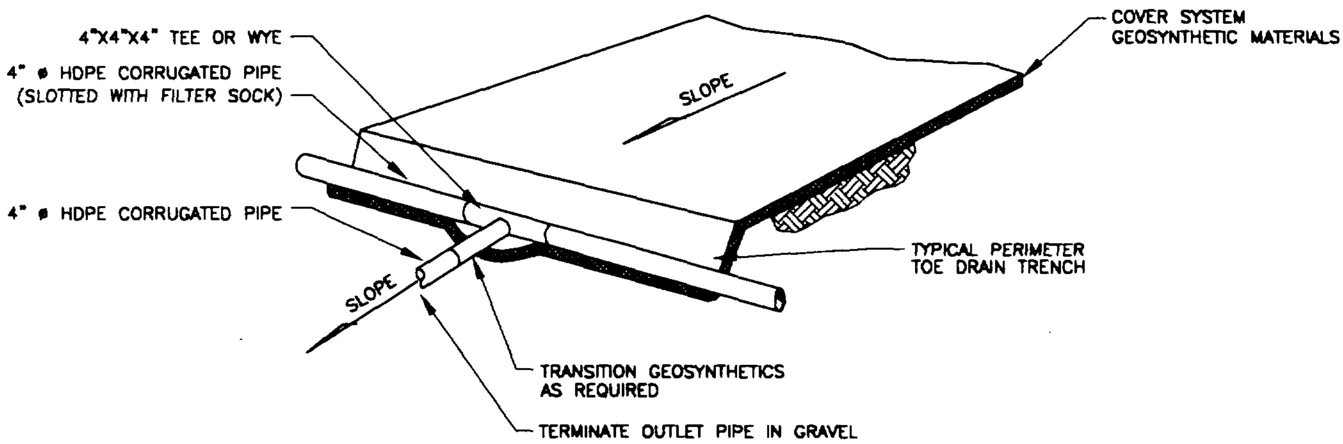
DOWNCHUTE SECTION

FIGURE
5-6



SLOPE ARMORING DETAIL

N.T.S.



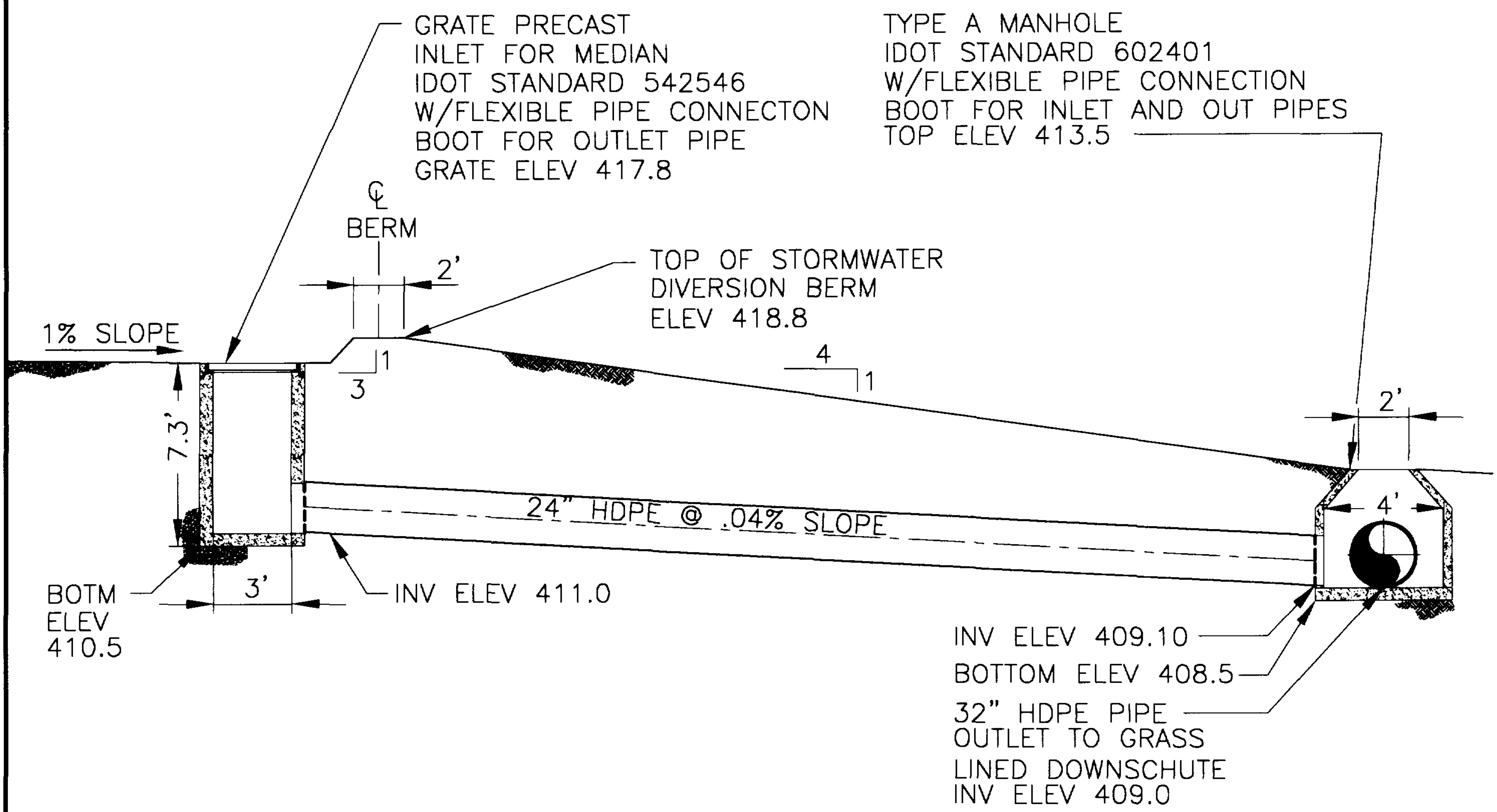
NOTE:
TOE DRAIN OUTLET PIPES LOCATED AROUND COVER PERIMETER AT 100FT CENTER TO CENTER.

TYPICAL TOE DRAIN OUTLET DETAIL

N.T.S.

PREPARED FOR: SOLUTIA	Drawn: W. WEBER	PROJECT NAME: SOLUTIA INC. SAUGET AREA 1	FIGURE
URS JOB NUMBER: C100004051.00	Design: GARY WANTLAND		
URS Corporation Southern, 7650 West Courtney Campbell Causeway, Tampa, FL 33607-1462, No. 00000002	Checked: GARY WANTLAND	DRAWING TITLE: COVER SYSTEM DETAILS	5-7
	Date: APRIL 2, 2001		

S:\C10000\4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 5-7.DWG 03/29/01 1:30

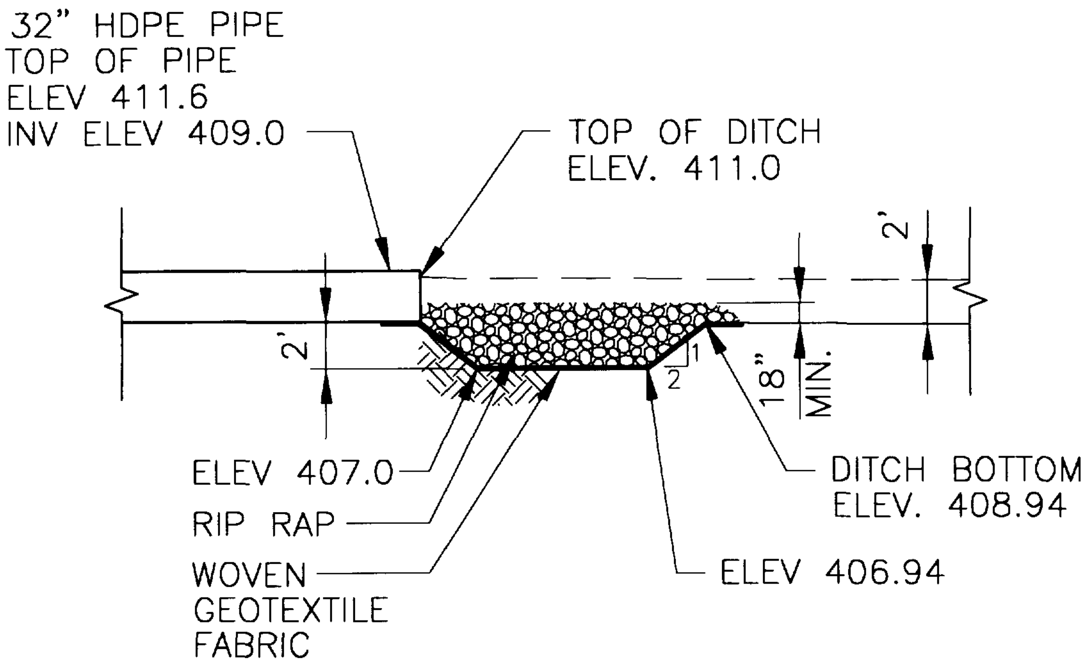


NOTE:

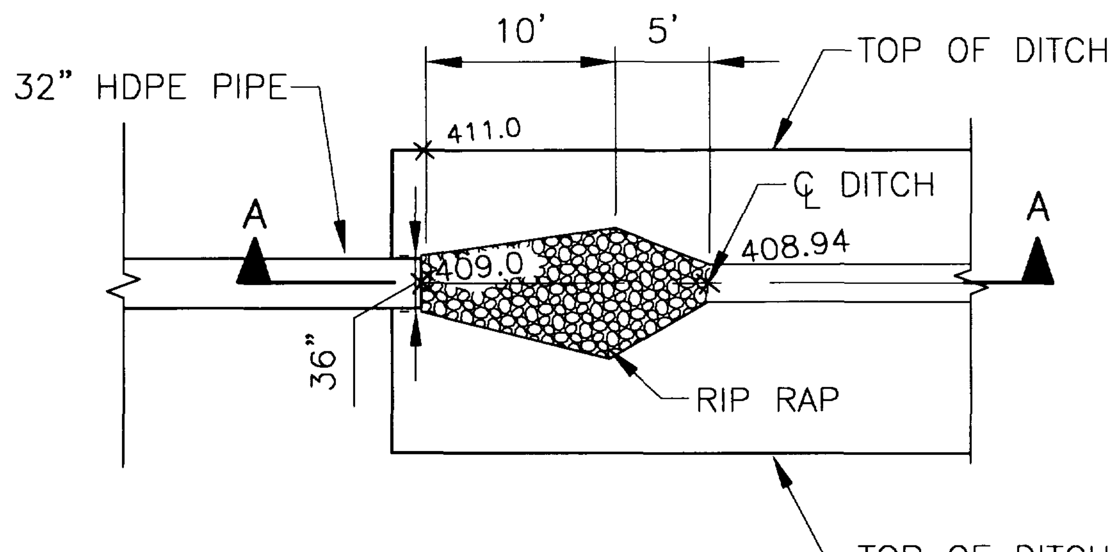
1. NOT FOR CONSTRUCTION.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS — URS Corporation Southern, 7650 West Courtney Campbell Causeway, Tampa, FL 33607-1462, No. 00000002	Drawn: BAD Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC.** **SAUGET AREA 1**	DRAWING TITLE **LANDFILL DROP STRUCTURE**	FIGURE 5-8



SECTION A–A



PLAN

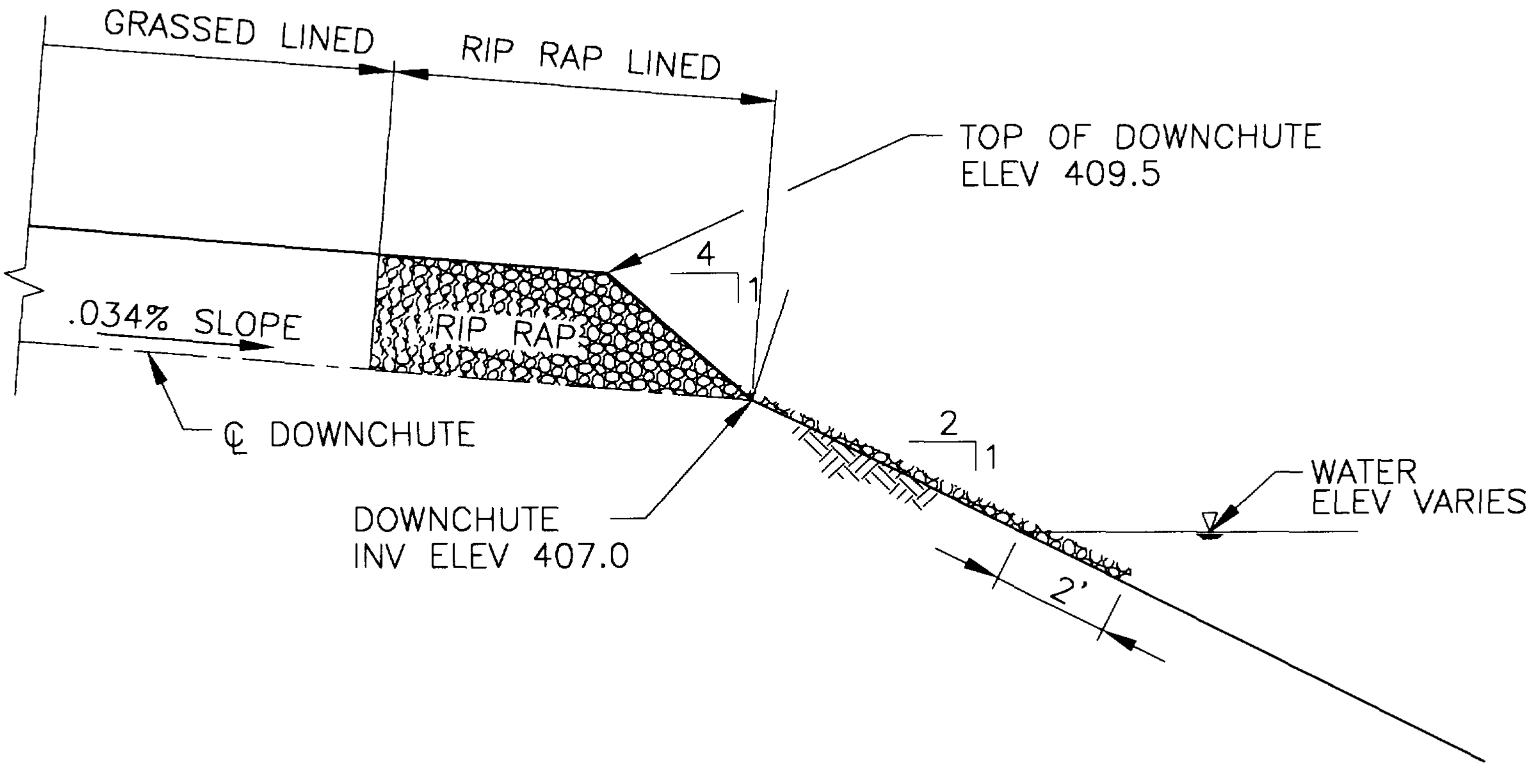
NOTE:

1. NOT FOR CONSTRUCTION.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1 DRAWING TITLE DOWNCHUTE OUTLET DETAIL	FIGURE 5-9

0000\4000\4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 5-9.DWG)8/01 14:04

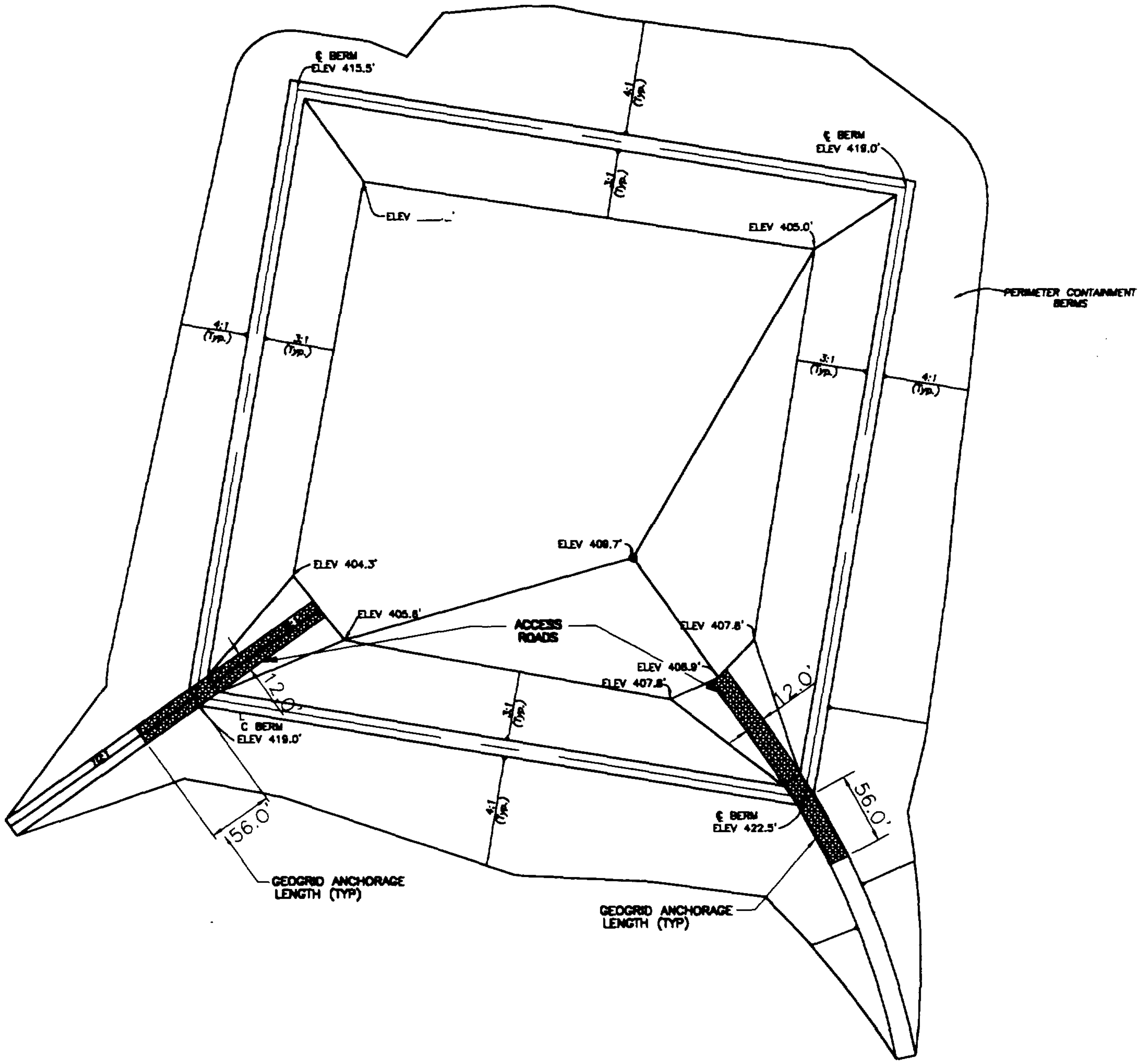


NOTE:

1. NOT FOR CONSTRUCTION.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: BAD Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC. SAUGET AREA 1**	DRAWING TITLE **RIPRAP LINED DOWNCHUTE AT DEAD CREEK OUTLET**	FIGURE 5-10



NOTE:

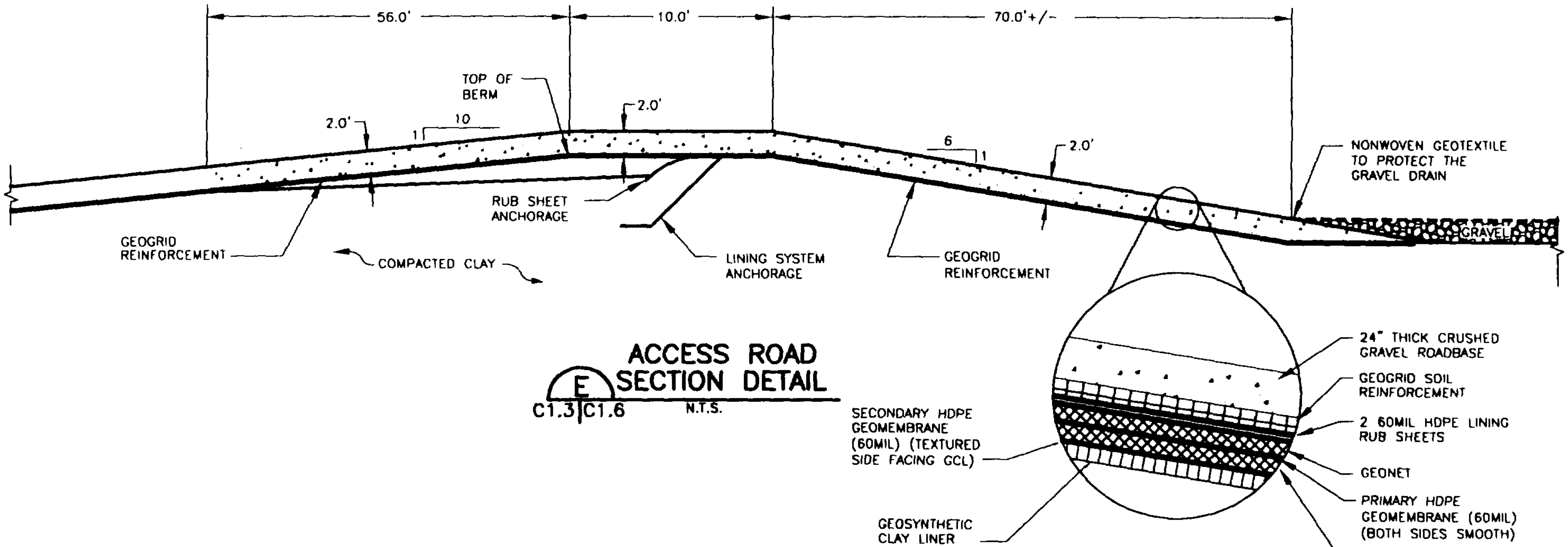
1. NOT FOR CONSTRUCTION.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC. SAUGET AREA 1** DRAWING TITLE **ACCESS ROAD PLAN**	FIGURE 6-1

S:\C10000\4000.0\FINAL DESIGN REPORT\FIGURES\FIGURE 6-1.DWG 03/29/01 11:58

S:\C10000\… \4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 6-2.DWG 03/29/0… 11:59



ACCESS ROAD SECTION DETAIL

E

C1.3 | C1.6 N.T.S.

NOTES:

1. NOT FOR CONSTRUCTION.
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: DRH Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	DRAWING TITLE ACCESS ROAD DETAIL	FIGURE 6-2

APPENDIX A

SITE CHARACTERIZATION

URS

December 21, 2000
23.99STL022.01

Mr. Bruce Yare
Manager, Remediation Technology
Solutia, Inc.
P.O. Box 66760
St. Louis, MO. 63166

Subject: Revised Report of Geotechnical Investigation For Cahokia Landfill Cell Cahokia, Illinois

Dear Bruce:

This letter transmits our revised report regarding the planned landfill cell in Cahokia, Illinois. This report updates and supercedes our previous report of December 2, 1999, based on two additional test borings and related laboratory testing. Findings based on the updated information are essentially similar to those presented in December of 1999, however, additional detail is provided.

We trust that this report meets your needs but will contact you shortly to discuss it.

Very truly yours,

William L. Durbin, P.E.
Vice President

Thomas L. Cooling, P.E.
Senior Geotechnical Engineer

cc: Gary Wantland

URS Corporation
2318 Millpark Drive
Maryland Heights, MO 63043
Tel: 314.429.0100
Fax: 314.429.0462

L:\GEO\Solutia\2399STL022.00\Solutia Revised Rpt Geo.doc

REVISED GEOTECHNICAL REPORT

DEAD CREEK SECTOR B CONTAINMENT CELL CAHOKIA, ILLINOIS

Prepared for
Solutia, Inc.
Enterprise Engineering
575 Maryville Centre Drive
St. Louis, MO 63141

December 21, 2000

URS

URS Corporation
2318 Millpark Drive
Maryland Heights, MO 63043
(314) 429-0100

Project 2399STL022.01 00003

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This report presents results of the geotechnical investigation for Solutia's proposed landfill cell in Cahokia, Illinois. It updates and supercedes a prior report of December 2, 1999, based on two additional test borings and related laboratory tests. This work was authorized under Solutia Purchase Order 4503140217; Change Order No. 1 dated November 14, 2000.

PROJECT UNDERSTANDING

We understand that the landfill will be located on the Solutia property formerly known as the Moto property. It is planned that the northern boundary of the cell will be adjacent to the southern boundary of Site G (Figure 1) and the eastern boundary of the cell adjacent to the west bank of Dead Creek. We understand the planned cell area is on the order of about 1.4 acres. Based on drawings provided by the designer, the height of the perimeter berms will be about 16 ft above current existing grade, and the height at the center of the landfill, when capped, will be about 19 ft above the existing grade. The exterior slopes of the containment berms will be 4H:1V and the interior slopes will be 3H:1V.

FIELD INVESTIGATION AND LABORATORY TESTING

The field investigation and laboratory testing were done in two episodes; first in 1999, then in 2000.

1999 Investigation

A total of four borings were drilled and a piezometer installed on the property between November 8, 1999 through November 10, 1999. Two hand-augers borings were drilled on November 15,1999. The geotechnical borings are designated GB-1 through GB-3, the piezometer is PZ-1, and the hand-auger borings are HA-1 and HA-2. Two borings, GB-1 and GB-3, were drilled to depths of about 50 ft and GB-2 was drilled to a depth of about 75 ft. Boring GB-2 was drilled deeper to estimate the vertical extent of loose to medium dense alluvium to help assess settlement and liquefaction potential of the site. The piezometer boring was drilled to a depth of about 20 ft and a piezometer was installed to that depth.

The borings were drilled with a CME-55 truck-mounted drilling rig owned and operated by Roberts Environmental Drilling, Inc. (REDI) of Illinois. Borings were advanced using 4-¼ inch I.D. hollow-stem augers. Once the water table was encountered, typically at a depth of between 9 to 14 ft below ground surface, borings were continued using a 3-7/8 inch diameter roller bit and a bentonite-based drilling mud.

Soil samples were obtained from the borings using either a 1-½ inch I.D. split-spoon sampler in accordance with the Standard Penetration Test (SPT) Method (ASTM D-1586) or a hydraulically pushed thin-walled sampler (ASTM D-1587) to obtain "undisturbed" samples.

Sampling was made at 2½-ft vertical intervals in the upper 10 ft and at 5-ft vertical intervals thereafter.

2000 Field Investigation

Two additional test borings, GB-4 and GB-5 were drilled on November 17, 2000 by Harriss Drilling under technical supervision of URS. Borings were advanced with 9 inch O.D. hollow stem augers using a CME-750 drilling rig to depths of 20 feet below grade. Continuous samples were obtained using either a standard split-spoon sampler (ASTM D-1586) or hydraulically pushed thin-walled tubes (ASTM – D1587). It was originally planned to use only thin-walled tube samples, but due to the predominantly granular nature of the soil, split-spoon samples were primarily taken.

For both episodes of drilling, the borings were tremmie grounted upon completion with a cement-bentonite mixture. Drilling spoils and excess sample were placed in containers provided by Solutia along with drilling fluids displaced during grouting.

Field boring logs were prepared by a URS representative based upon recovered soil samples, cuttings, and drilling characteristics. The logs have been subsequently modified to reflect laboratory test results. Boring locations are shown in Figure 1 and a graphic subsurface profile is shown in Figure 2. Detailed boring logs are given in Appendix A.

LABORATORY TESTING

Laboratory tests were performed on selected samples from each episode of drilling. The types of tests performed are given in the following table. Test results are given in Appendix A.

Summary of Laboratory Tests Performed	
Test Name	ASTM Designation
Unit weight+ Water Cont.	D2937
Classification of Soil	D2487
Water Content	D2216
Liquid and Plastic Limit	D4318
Sieve +Hydrometer	D422
Percent Fines	D1140

Summary of Laboratory Tests Performed	
Consolidation	D2435
Unconfined Compression	D2166
Unconsolidated Undrained Triaxial	D2850
Specific Gravity	D854

SUBSURFACE PROFILE

The subsurface profile consists of four primary soil strata above limestone bedrock. These strata beginning from the ground surface and extending downward are as follows:

Summary of Key Soil Strata			
Strata Number	Depth below grade (ft)		Description
	From	To	
1	0	4	Firm low to medium plastic CLAY
2	4	20	Very loose to loose SILT and Sandy SILT
3	20	50	Loose to medium dense Silty SAND and SAND
4	50	100*	Dense to very dense SAND and Sitly SAND with trace gravel.

*This stratum is assumed to extend to limestone bedrock at a depth of approximately 100 ft below the ground surface. (Figure 3).

A summary of soil properties for these key strata used for analysis is given in Table 1.

GROUNDWATER

In the 1999 explorations, the water surface was encountered between depths below grade of 9 and 15 ft in all borings at the time of drilling on November 8, 1999. In each of the 2000 borings, groundwater was first encountered at depths of about 15 ft below grade, but rose to between 7 and 8 feet (elevation 390 to 395) shortly after drilling. Groundwater elevations in the piezometer varied between El. 391.8 and 392.5 during November and December of 1999. A summary of groundwater elevations from the borings and piezometer are given in Table 2. Groundwater elevations likely fluctuate seasonally with the stage of the Mississippi River.

ENGINEERING ANALYSES AND RECOMMENDATIONS

The landfill cell will consist of exterior compacted fill dikes and will contain a liner system, waste material, and liner cap. Geotechnical analyses were performed to evaluate Foundation and Mass Stability according to IEPA requirements (Title 35 of the Illinois Administrative Code, Section 811.304). Analyses included:

- Static bearing capacity,
- Static stability of exterior slopes,
- Settlement of the landfill,
- Seismic evaluation including liquefaction triggering, seismically induced settlement, seismic bearing capacity and seismic slope stability. Results of these analyses are summarized in the following paragraphs.

Settlement Analyses

Analyses of the landfill were performed to estimate settlement at various locations in the landfill.

Soil properties assumed for design were determined from the consolidations tests (for the upper clayey and silty soils), and from Standard Penetration Test data for the underlying sands. For design purposes groundwater was assumed at grade. Analysis was performed using UniSettle software. Results are shown in Figure 5 which indicates a maximum total settlement of about 4 inches which occurs at the center of the landfill and a minimum of about 0.4 inches near the toe of the outboard berms. Because of the granular nature of the foundation soils, and over consolidation of the clay, we anticipate that most settlement will occur during fill placement. Settlement is estimated to be essentially complete within 60 days after completion of the cell.

Liquefaction induced settlement due to earthquake shaking will add to the static settlement as discussed in subsequent sections of this report.

Slope Stability Analyses

We evaluated the stability of the out-board 4H:1V slopes of the proposed landfill. This analysis was an undrained analysis performed using the slope-stability program Slope-W based on Spencer's Method of Analysis. Soil properties for the various strata were determined based upon laboratory test results, and Standard Penetration Test results. The compacted embankment properties were based upon local experience with similar type soils. Both circular and noncircular surfaces were searched for the minimum factor of safety. The highest proposed slope was analyzed, as it is the most critical case. Results of the analysis are plotted in Figure 5, which indicate a static factor of safety of 2.5, which exceeds the IEPA required value of 1.5.

The outboard slopes were also evaluated for the seismic case as noted in subsequent sections of this report.

Bearing Capacity

For a large flexible structure such as the proposed landfill with sloped beams at the perimeter, bearing capacity is an unlikely mode of failure. Rather, the controlling mode of foundation failure is the potential for slope instability of the outboard slopes. Slope stability analysis discussed above, indicates an acceptable factor of safety.

Seismic Evaluation

East St. Louis is an area of moderate seismicity. The estimated bedrock acceleration (PGA) based on 1996 USGS[1] maps is about 0.1g for a 10 percent probability of exceedance in 50 years. This value is very close to the design bedrock acceleration of 0.11g required by IDOT for design of structures. The corresponding earthquake magnitude is approximately (Ms) 6.5 based on USGS data. The soils above rock will tend to amplify the bedrock motion resulting in a higher acceleration near the ground surface. The surface acceleration was estimated based on NEHRP 1997[2] criteria, which indicate an amplification factor of about 1.6 for this soil profile. The design ground surface design acceleration is therefore 0.16g with a corresponding earthquake magnitude (Ms) of 6.5.

The two analyses performed included liquefaction triggering (to determine if accelerations were large enough to cause liquefaction) and pseudo-static slope stability analysis of the outboard slopes.

Liquefaction Triggering

The liquefaction potential of the site was evaluated using the "simplified procedure" by Seed and Idriss, (1972) as updated in NCEER, 1997[3]. Based on this analysis, the factor of safety against liquefaction triggering was calculated versus depth. Results are shown in Figure 6. Analysis shows that the Factor of Safety is typically much greater than 1.0 indicating that liquefaction is not likely to be triggered at the site. However, some settlement due to shaking is likely and estimated to be up to about 3 inches. This would be added to the static settlement noted above. The consequences of damage to the liner and the foundation are judged to be tolerable for this seismically induced settlement.

---

[1] United States Geologic Survey, National Seismic Hazard Mapping Project, 1996, URL: http://geohazards.cr.usgs.gov/eq/
[2] National Earthquake Hazard Reduction Program, Federal Emergency Management Agency (FEMA 303), NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, 1997.
[3] Youd, T. Leslie and Idriss, Izzat M. (1997) "Proceeding of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils." Technical Report NCEER-97-0022, December 31. 1088-3800

Seismic Slope Stability

Psuedo-static slope-stability analysis was run assuming an acceleration of 0.16 g for the outboard slopes. Results are given in Figure 7, which indicate a factor of safety of 1.5, which is in excess of the IEPA required value of 1.3.

SUMMARY AND CONCLUSIONS

1. The site is underlain by a near-surface loose silt and firm clay layer that extends to a depth of approximately 20 ft below grade. This stratum is underlain to bedrock by sand that is typically medium dense near its surface and increases in density with depth, becoming dense to very dense. Limestone bedrock is estimated to be about 100 ft below surface grade.
2. Groundwater is present about 10 ft below grade, and varies in elevation seasonally with the stage of the Mississippi River.
3. The bedrock acceleration due to seismic shaking, based on a 500 year design period, is estimated by USGS to be 0.1 g with a resulting ground surface acceleration of approximately 0.16 g.
4. The potential for seismically induced liquefaction is judged to be small, however some seismically induced settlement, about 3 inches, is possible if the design ground motion occurs.
5. Static settlement of the landfill is estimated to be a maximum of approximately 4 inches at the center, and less than one inch near the toe of the perimeter berms. The estimated settlement is considered tolerable for the landfill.
6. Stability of the outboard slopes, for both static and seismic conditions meets or exceeds the IEPA requirements.
7. Due to its flexibility and shape (outboard slopes), bearing capacity failure of the landfill is not a likely mode of failure. A more probable mode of foundation failure would be slope stability, which has been shown to meet IEPA requirements.
8. The proposed landfill is judged to be acceptable and meet IEPA requirements for Foundation and Mass Stability.

LIMITATIONS

The boring logs and piezometer indicate conditions for the specific locations and dates. Non-uniform conditions, however, can exist between borings, which if encountered may require some field modifications to the landfill design. This contingency should be considered and a budget allowance established.

Table 1
Summary of Data for Key Strata

Solutia Inc. - Sauget Area 1
Cahokia, Illinois

Stratum	N (blows/ft)			w_{nat} (%)			LL (%)			PL (%)			γ_{tot} (pcf)			s_u (tsf)	P_c (tsf)	$C_c/(1+e_0)$	$C_r/(1+e_0)$	Minus No. 200 (%)	D_{10} (mm)	K (cm/sec)
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg							
1	9	3	6	36	6	23	60	34	42	24	14	20	116	92	108	0.44	3	0.08	0.009	65-98	< 0.001	10^{-6} - 10^{-7}
2	10	0	5	37	6	26	38	32	35	25	19	22	115	89	107	0.25	3	0.10	0.012	18-99	< 0.001 - 0.02	10^{-4} - 10^{-6}
3	48	7	21	32	18	24	-	-	-	-	-	-	-	-	-	-	-	-	-	2-46	< 0.001 - 0.1	10^{-3} - 10^{-4}
4	79	37	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Description of Soil Strata:

1. Firm, moist, low to medium plastic, Silty CLAY (CL)
2. Very loose to loose, dry to wet, SILT to Sandy SILT (ML) with possibly some Clay lenses
3. Loose to medium dense, wet, Silty SAND to SAND (SM,SP)
4. Dense to very dense, wet, Silty SAND to SAND (SM, SP) with a trace of gravel

N - Number of blows per inch from standard penetration test
w_{nat} - Natural water content
LL - Liquid limit of material
PL - Plastic limit of material
g_{tot} - Total unit weight of material
s_u - Undrained shear strength
P_c - Preconsolidation pressure
$C_c/(1+e_o)$ - Compression raio, strain per log of stress beyond preconsolidation pressure
$C_r/(1+e_o)$ - Recompression ratio, strain per log of stress below preconsolidation pressure
No. 200 - Percentage passing the 200 sieve
D_{10} - Diameter at which 10% of the soil finer
K - Coefficient of permeability from consolidation test or estimate from gradation

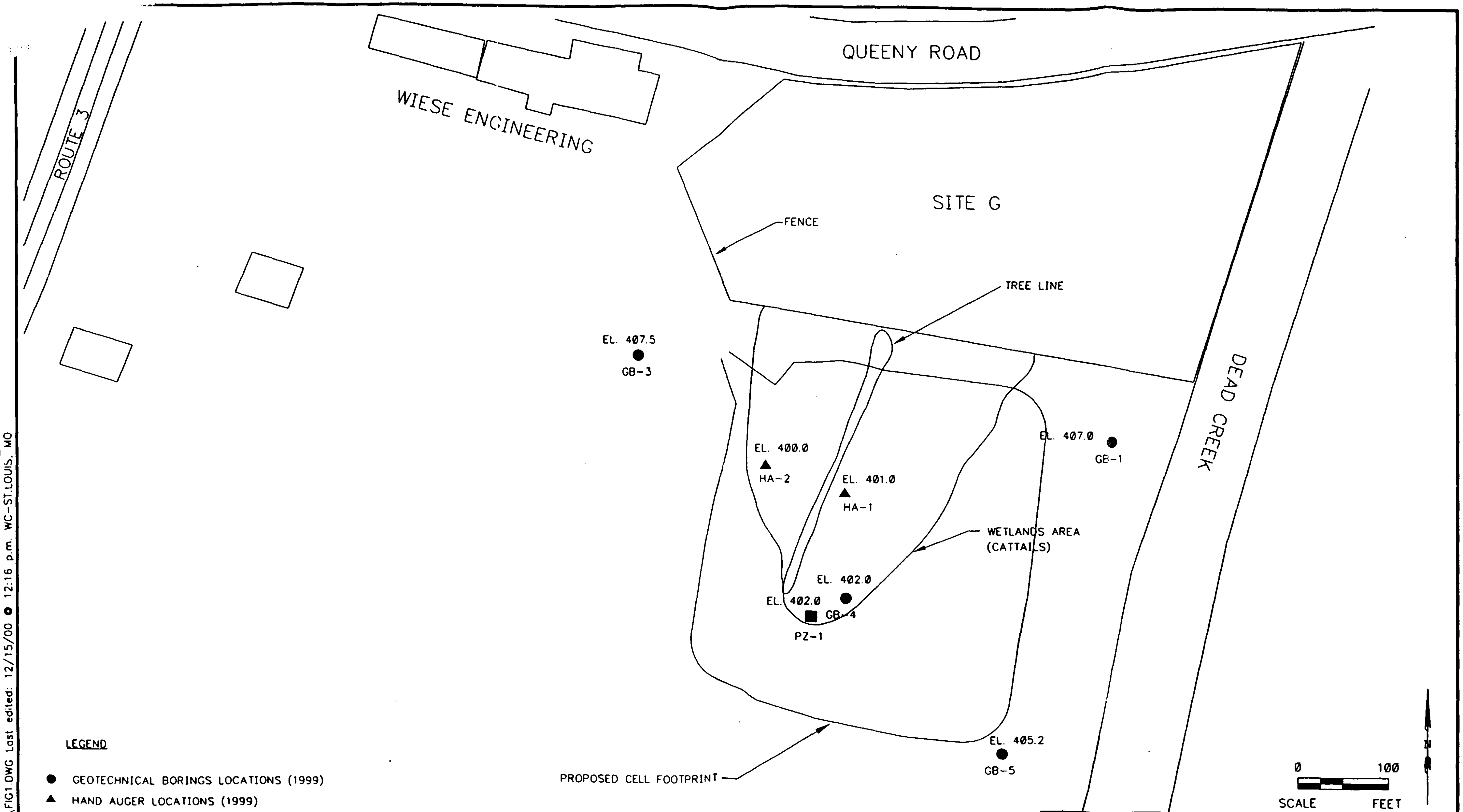
Table 2
Summary of Water Level Readings
Solutia Inc. TSCA Cell
Cahokia, IL

Date	Time (HRS)	GB-1 Elev. (FT) 407		GB-2 Elev. (FT) 407		GB-3 Elev. (FT) 407.5		GB-4 Elev. (FT) 402		GB-5 Elev. (FT) 405.2		PZ-1 Elev. (FT) 402	
		Depth (FT.)	Elevation (FT.)	Depth (FT.)	Elevation (FT.)	Depth (FT.)	Elevation (FT.)	Depth (FT.)	Elevation (FT.)	Depth (FT.)	Elevation (FT.)	Depth (FT.)	Elevation (FT.)
11/08/1999	ATD	10	397.0									9.5	392.5
	18 hrs. after drilling											10	392.0
11/09/1999	ATD			14	393.0								
11/10/1999	ATD					10.5	397.0						
11/15/1999												9.77	392.2
11/22/1999												9.95	392.1
12/01/1999												10.22	391.8
11/07/2000	ATD							15.5	386.5				
	3 hrs after drilling							7.1	394.9				
11/07/2000	ATD									15	390.2		
	1 hrs after drilling									8	397.2		

ATD - At time of drilling

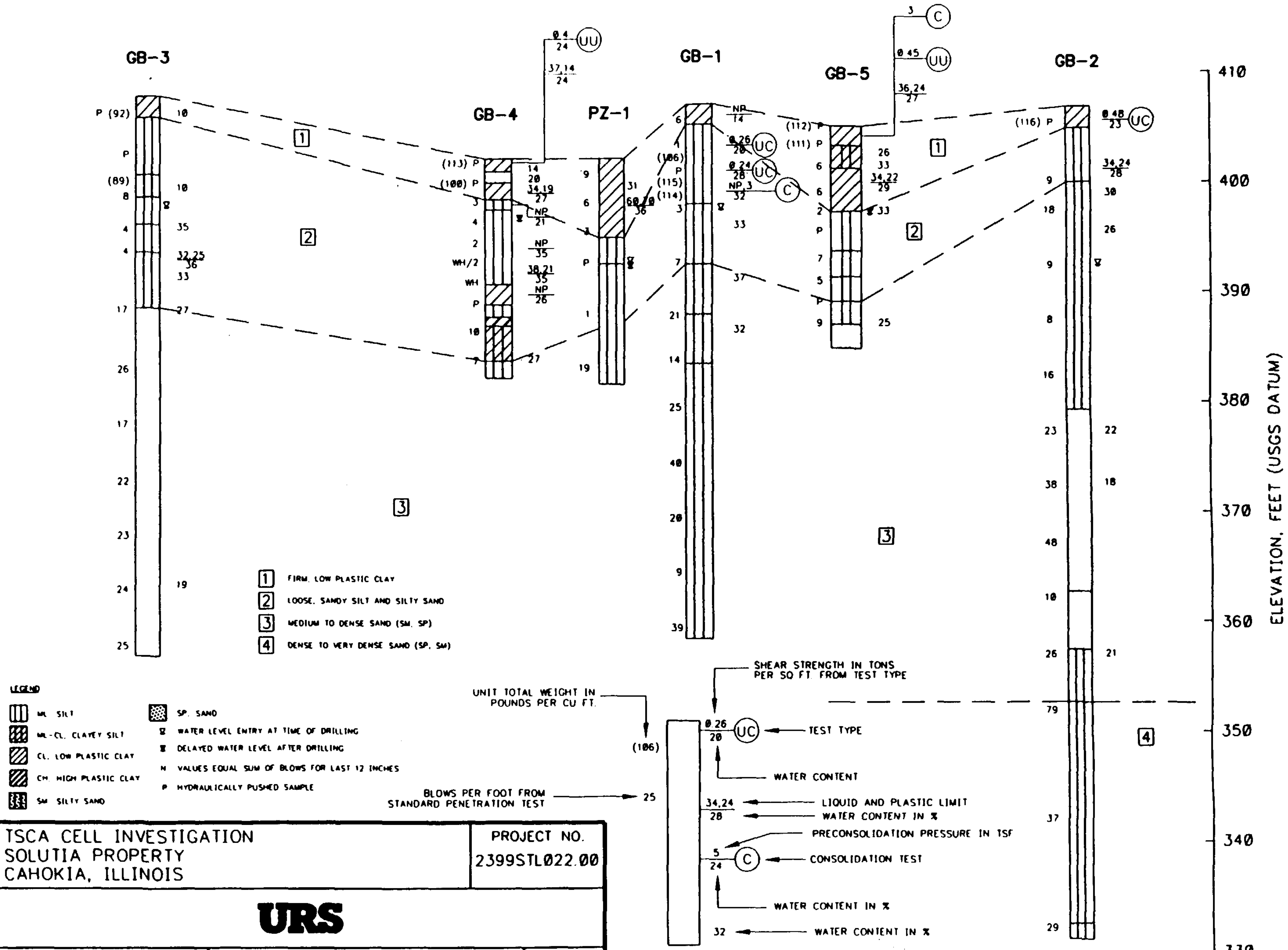
FIGURES

File: S:\ADMIN\CADD\FIG1.DWG Last edited: 12/15/00 @ 12:16 p.m. WC-ST.LOUIS, MO



TSCA CELL INVESTIGATION SOLUTIA PROPERTY CAHOKIA, ILLINOIS	PROJECT NO. 2399STL022.00
URS	
DRN. BY: wdl 12/15/00 DSGN. BY: CHKD. BY:	Boring Plan Location — FIG. NO. 1

File: E:\99STL022\BORING PROFILE.DWG Last edited: 12/21/00 @ 11:02 a.m. WC-ST.LOUIS, MO



TSCA CELL INVESTIGATION SOLUTIA PROPERTY CAHOKIA, ILLINOIS	PROJECT NO. 2399STL022.00

URS

DRN BY: djd 12/15/00 DSGN. BY: tlc CHKD. BY:	Subsurface Profile	FIG. NO. 2

NOTES: THESE GRAPHIC LOGS DEPICT GENERALIZED SOIL CONDITIONS. REFER TO INDIVIDUAL LOGS FOR DETAILS

ILLINOIS STATE GEOLOGICAL SURVEY

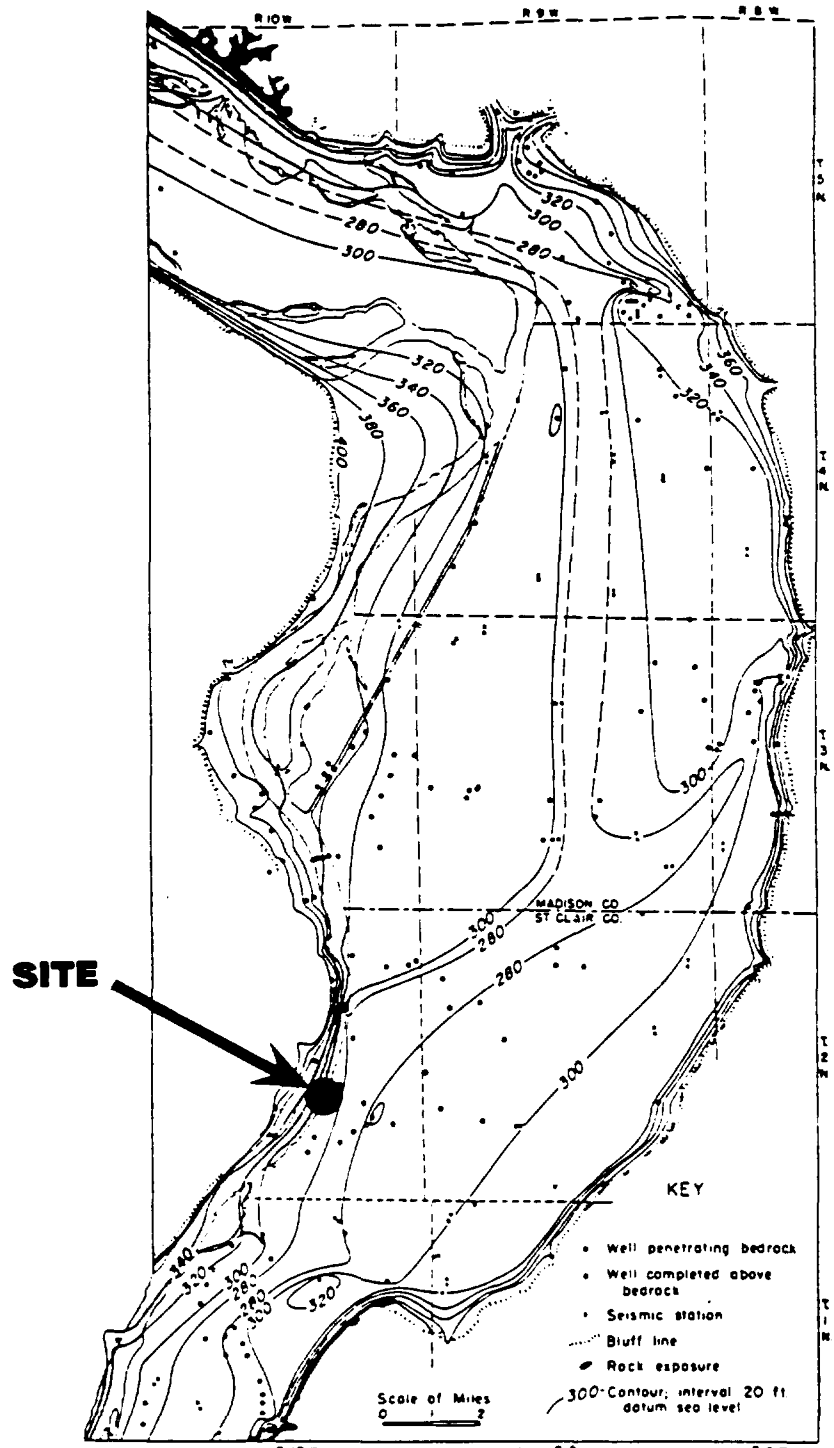


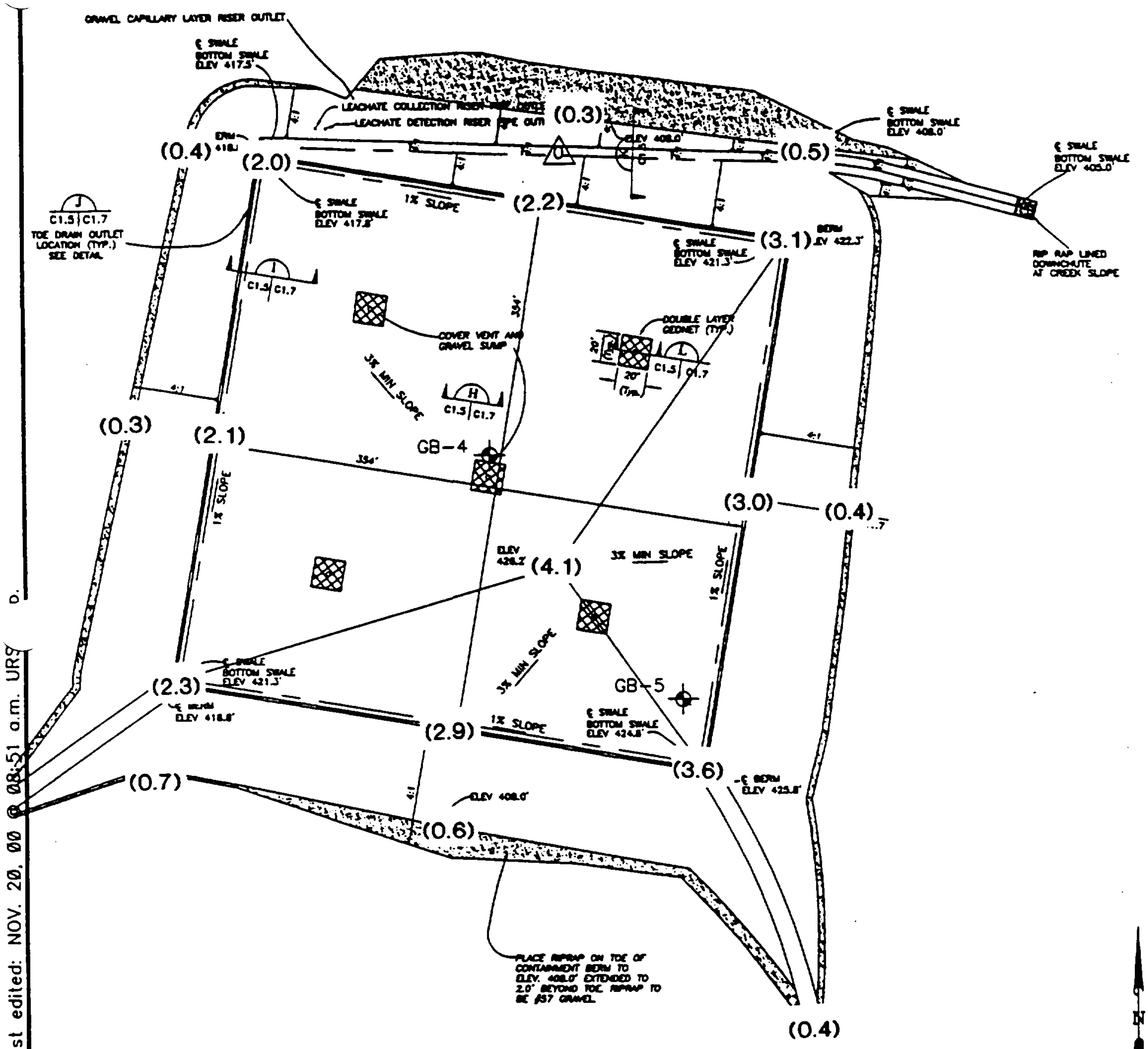
FIG. 2.—Bedrock surface map of the East St. Louis area, Ill.

Reference: Map taken from Groundwater Geology of the East St. Louis Area, Illinois, R. Bergstrom and T. Walker, 1956.

TSCA CELL INVESTIGATION SOLUTIA PROPERTY CAHOKIA, ILLINOIS	PROJECT NO. 2399STL022.00

URS

DRN BY wdl 12/15/00 DSGN BY CHKD BY	Bedrock Elevation Map	FIG NO 3



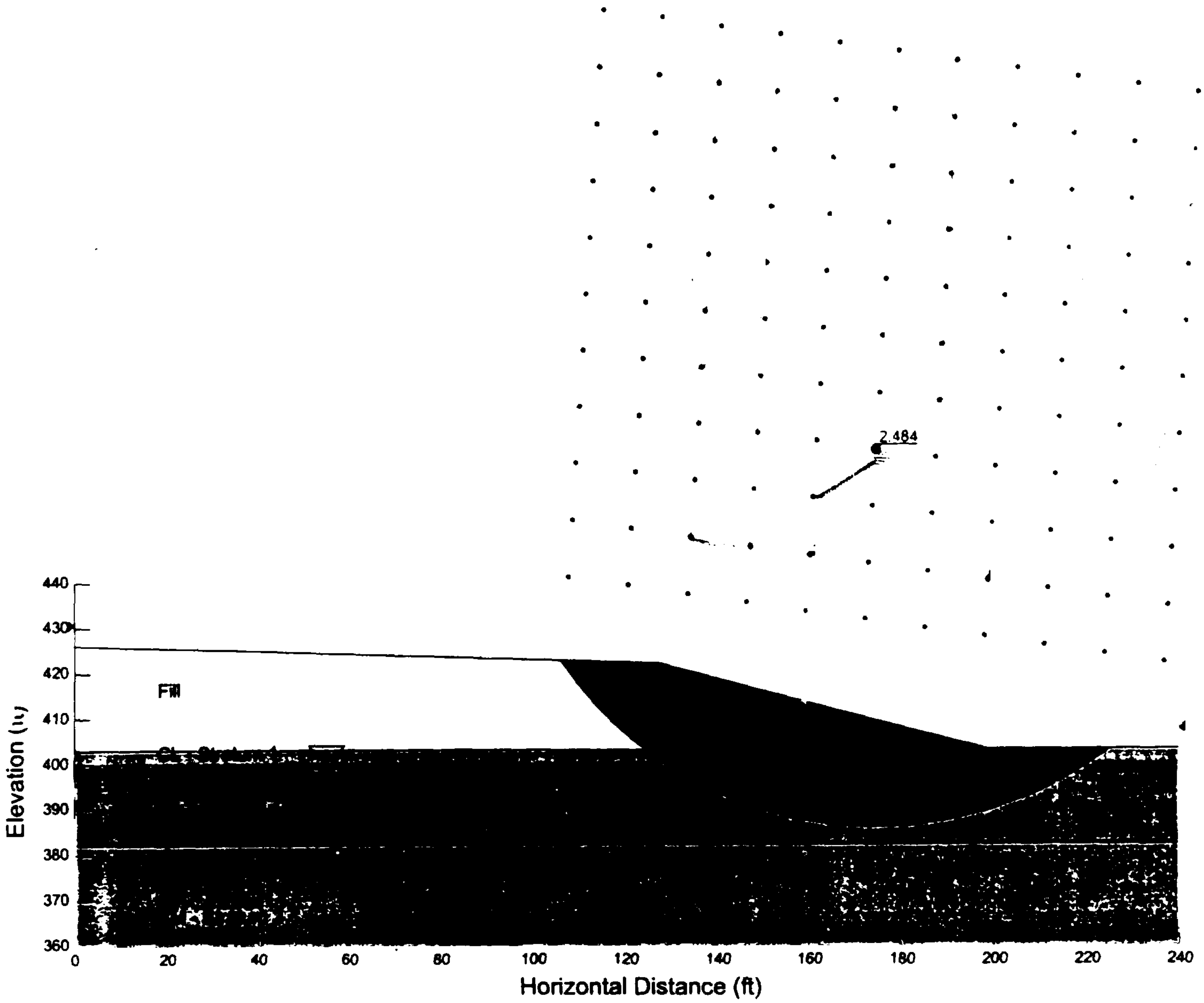
LEGEND

BORING LOCATION

(6.0) - ESTIMATED TOTAL SETTLEMENT

TSCA CELL INVESTIGATION SAUGET AREA 1 CAHOKIA, ILLINOIS	PROJECT NO. 2399STL022.01
URS	
DRN. BY: djd 11/20/00 DSGN. BY: tlc CHKD. BY:	Estimated Total Settlements Plan View — FIG. NO. 4

File: E:\STL022\C1.5.DWG Last edited: NOV. 20, 00 @ 08:51 a.m. URS



Fill
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 2000
Piezometric Line #: 1

CL - Stratum 1
Soil Model: Undrained (Phi=0)
Unit Weight: 108
Cohesion: 880
Piezometric Line #: 1

ML - Stratum 2
Soil Model: Undrained (Phi=0)
Unit Weight: 107
Cohesion: 500
Piezometric Line #: 1

SM - Stratum 3
Soil Model: Mohr-Coulomb
Unit Weight: 115
Cohesion: 0
Phi: 28
Piezometric Line #: 1

Solutia Inc. Sauget Area 1 - Cahokia, Illinois
Undrained Analysis
File Name: Slp stab - undrained.slp
Last Saved Date: 12/4/00
Last Saved Time: 12:32:30 PM
Analysis Method: Spencer
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric Lines / Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

Project No. 2399STL022.01	Solutia, Cahokia, IL.	Static Slope Stability Analysis Results, Outboard Slopes of TSCA Cell	FIGURE 5
URS CORPORATION			

Factor of Safety Against Liquefaction Triggering vs. Depth for Solutia, Inc. (TSCA Cell)

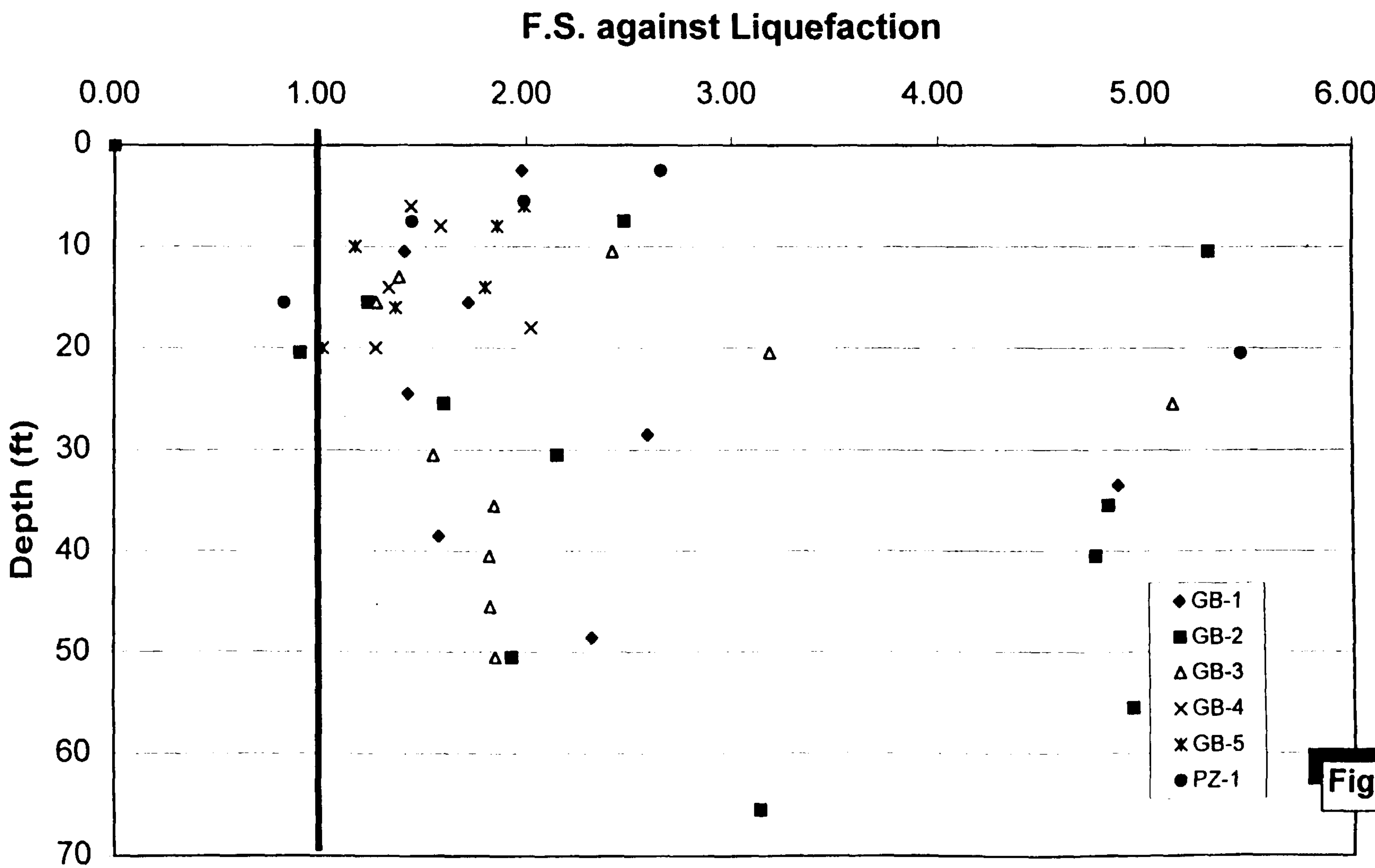
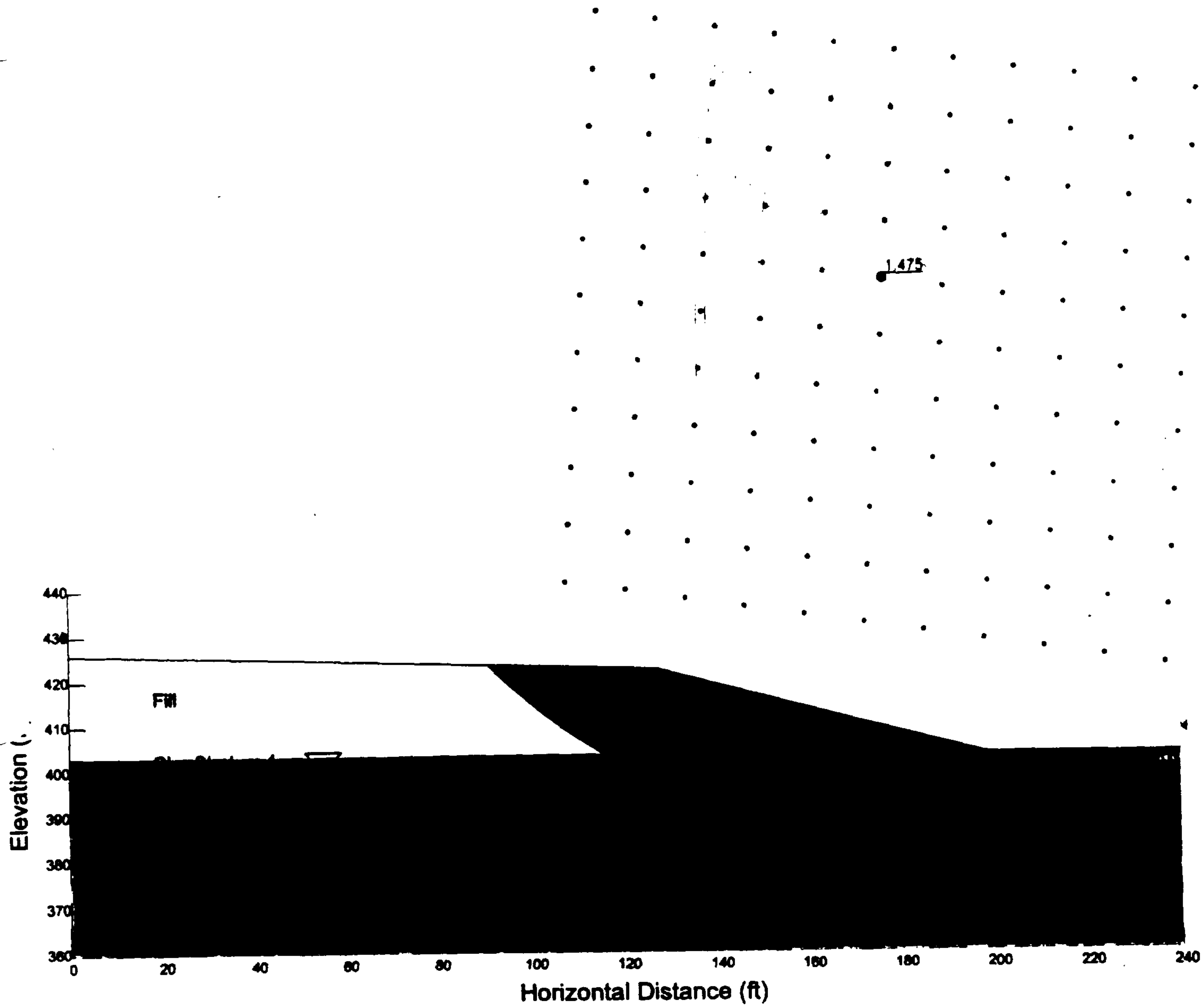


Figure 6

K:geo\solutia\2399STL0022.00\Lique-Solutia-SPTgwt10ftIdriss99goodata

12/15/00



Fill
Soil Model: Undrained (Phi=0)
Unit Weight: 125
Cohesion: 2000
Piezometric Line #: 1

ML - Stratum 2
Soil Model: Undrained (Phi=0)
Unit Weight: 107
Cohesion: 500
Piezometric Line #: 1

CL - Stratum 1
Soil Model: Undrained (Phi=0)
Unit Weight: 108
Cohesion: 880
Piezometric Line #: 1

SM - Stratum 3
Soil Model: Mohr-Coulomb
Unit Weight: 115
Cohesion: 0
Phi: 28
Piezometric Line #: 1

Solutia Inc. Sauget Area 1 - Cahokia, Illinois
Undrained Analysis
File Name: Slp stab - undrained - seismic 0.16g.slp
Last Saved Date: 12/14/00
Last Saved Time: 7:40:58 AM
Analysis Method: Spencer
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric Lines / Ru
Tension Crack Option: (none)
Seismic Coefficient: Horizontal

Project No. 2399STL022.01	Solutia, Cahokia, IL.	Seismic Slope Stability Analysis Results, Outboard Slopes of TSCA Cell	FIGURE 7
URS CORPORATION			

Boring Logs

KEY TO BORING LOGS

Group	Description	USC Class.
GRAVEL	GRAVEL with little or no fines	GP or GW
GRAVEL	Silty GRAVEL	GM
GRAVEL	Clayey GRAVEL	GC
SAND	SAND with little or no fines	SP or SW
SAND	Silty SAND	SM
SAND	Clayey SAND	SC
LOW PLASTIC SILTS AND CLAYS	Inorganic low plastic SILT	ML
LOW PLASTIC SILTS AND CLAYS	Inorganic low plastic CLAY	CL
LOW PLASTIC SILTS AND CLAYS	Silty	CL
LOW PLASTIC SILTS AND CLAYS	Sandy	CL
LOW PLASTIC SILTS AND CLAYS	Gravelly	CL
LOW PLASTIC SILTS AND CLAYS	Organic low plastic SILT or CLAY	OL
HIGH PLASTIC SILTS AND CLAYS	Inorganic high plastic SILT	MH
HIGH PLASTIC SILTS AND CLAYS	Inorganic high plastic CLAY	CH
HIGH PLASTIC SILTS AND CLAYS	Organic high plastic SILT or CLAY	OH
	Peat and other highly organic soils	PT
ROCKS	LIMESTONE	
ROCKS	SHALE	
ROCKS	SANDSTONE	
ROCKS	SILTSTONE	
SURFACE MATERIALS	Topsoil or pavement	
SURFACE MATERIALS	FILL	

TERMS DESCRIBING CONSISTENCY OR CONDITION

Coarse grained soils (major portion retained on No. 200 sieve): Includes gravels and sands. Condition is rated according to the Standard Penetration Resistance, as shown below.

Descriptive Term	Blows per Foot
Very loose	0 - 5
Loose	5 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	Greater than 50

Fine grained soils (major portion passing No. 200 sieve): Includes clays and silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests.

Descriptive Term	Unconfined Compressive Strength, tons/sq.ft	Hand Test
Very soft	less than 0.25	Extrudes between fingers
Soft	0.25 - 0.50	Molded by slight pressure
Firm	0.50 - 1.00	Molded by strong pressure
Stiff	1.00 - 2.00	Indented by thumb
Very stiff	2.00 - 4.00	Indented by thumbnail
Hard	4.00 and higher	Difficult to indent

LEGEND AND NOMENCLATURE

Standard Penetration Sample

Liner-tube sample, obtained by penetration of thick wall sampler containing 2 in. diameter liner-tubes (California sampler).

Undisturbed sample, obtained by penetration of minimal 3 in. diameter, thin wall tube or, where indicated, fixed-piston sampling head.

NX core.

PP,tsf — Unconfined compressive strength in tsf estimated with pocket penetrometer.

TV,tsf — Undrained shear strength in tsf estimated with torvane.

NMC,% — Natural Moisture Content, %

LL — Liquid Limit

PI — Plasticity Index

Qu, ksf — Unconfined Compressive Strength (Laboratory), ksf

RQD=80% — Percentage (80) of Rock Quality Designation

Depth Groundwater enters at time of drilling.

Groundwater Level at some specified time after drilling.

SAMPLING RESISTANCE

P — Sample pushed by hydraulic rig action.

3
6
9 — Numbers indicate blows per 6 in. of sampler penetration when driven by a 140 lb hammer falling freely 30 in. The Standard Penetration Resistance is the number of blows for the last 12 in. of penetration of the Standard Penetration sampler, e.g. 15.

15 — Standard Penetration Resistance

50/2 — Number of blows (50) used to drive the Standard Penetration Sampler a certain number of inches (2).

ABBREVIATIONS USED UNDER "FIELD NOTES"

HSA = Hollow Stem Auger
CFA = Continuous Flight Auger
ATD = At Time of Drilling
AD = After Drilling
DWL = Drill Water Loss
DWR = Drill Water Return

LOG of BORING No. GB-1

DATE 11/8/99 SURFACE ELEVATION, FT 407.0 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
0			Firm, dark brown, moist, low plasticity Silty CLAY (CL)								Boring advanced with 4 1/4in. I.D HSA and Mud rotary
	4, 3, 3	100		405.2							
			Loose tan, dry, fine Sandy SILT (ML)	1.8			14				
		83									
5						0.5	20				
							19				
		83					18				
						0.5	22				
			Becoming moist				28				
							33				
							35				
				398.0			32				
	2, 1, 2	100	Very loose, tan, wet, SILT (ML); with trace of clay and some fine sand	9.0							
10							33				
			Becoming loose								
	4			392.5							
15	4, 3		Loose, wet, tan, fine Silty SAND (SM)	14.5							Switch to Mud Rotary
							37				
				388.0							
20	7, 11, 10	83	Medium dense, tan, wet fine Sandy SILT, to Silty SAND (SM/ML)	19.0							
							32				
	7	72		383.5							
	6, 8		Medium dense, tan, wet, medium to fine Silty SAND (SM)	23.5							

Completion Depth: 48.5 Ft. Water Depth: 10 ft., After ATD

Project No.: 2399STL022 ft., After hrs.

Project Name: Solutia ft., After hrs.

Drilling Contractor: Redi Logged by: Tim Hicks

12/2/99 WCCXS TL022

URS Greiner Woodward Clyde

LOG of BORING No. GB-1

DATE 11/8/99 SURFACE ELEVATION, FT 407.0 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLES	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
25													
		6 10 15	83	Becoming gray, medium dense, medium to fine gravel									
30				Medium dense, gray Silty SAND (SM); with trace of medium to fine gravel									
		16 19 21	83	Becoming dense and less silty									
35													
		10 12 8	67	Becoming medium dense									
40													
		5 5 4	67	Becoming loose									
45				Loose, wet, gray Silty SAND (SM)									
		16 11 18		Becoming medium dense	358.5								
				Bottom of boring at 48.5ft.	48.5								

Completion Depth: 48.5 Ft.
Water Depth: 10 ft., After ATD hrs.
Project No.: 2399STL022
ft., After hrs.
Project Name: Solutia
ft., After hrs.
Drilling Contractor: Redi
Logged by: Tim Hicks

URS Greiner Woodward Clyde

Figure A-2

LOG of BORING No. GB-2

DATE 11/9/99 SURFACE ELEVATION, FT 407.0 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
0		33	Brown, soft, moist, low plasticity Silty CLAY (CL)	405.0 / 2.0		1.0	22, 23				Boring advanced with 4 1/4in. I.D HSA and Mud Rotary
			Loose, tan, dry, fine Sandy SILT (ML)				19				
5		58	Becoming Medium dense, gray with iron staining								
	5, 4, 5	49		400.0 / 7.0			28	34	10		
			Loose, moist, gray, fine Silty SAND (SM)				30				
10	5, 10, 8	89	Becoming medium dense, light brown and gray				26				
15	3, 4, 5	67	Becoming loose and saturated								Switched to Mud Rotary
20	5, 4, 4	78	Trace of fine gravel, becoming coarse to fine sand								
	4	67	Becoming medium dense with a trace of medium to fine gravel								

Completion Depth: 75.5 Ft.
Project No.: 2399STL022
Project Name: Solutia
Drilling Contractor: Redi

Water Depth: 14 ft., After ATD
ft., After hrs.
ft., After hrs.
Logged by: Tim Hicks

12/2/99 WCCXS TL022

URS Greiner Woodward Clyde

LOG of BORING No. GB-2

DATE 11/9/99 SURFACE ELEVATION, FT 407.0 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLES	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
25		6 10		Medium dense, gray, wet Silty SAND (SM); with a trace medium to fine gravel									
30		5 10 13		Medium dense, gray, wet Silty SAND (SM)					22				
35		15 19 19	67	Becoming dense					18				
40		9 20 28	78	With fine gravel, decrease in silt content	363.0 44.0								
45		5 6 4	78	Loose, medium dense, moist, gray coarse to fine SAND (SP); with some fine gravel	357.7 49.3								
		6	78										

Completion Depth: 75.5 Ft. Water Depth: 14 ft., After ATD hrs.

Project No.: 2399STL022 ft., After hrs.

Project Name: Solutia ft., After hrs.

Drilling Contractor: Redi Logged by: Tim Hicks

Figure A-2

LOG of BORING No. GB-2

Sheet 3 of 4

DATE 11/9/99 SURFACE ELEVATION, FT 407.0 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLES	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
50		13 13		Medium dense, gray, moist, medium to fine SAND (SM/SP); with trace of silt	353.0				21				
55		30 39 40	100	Very dense, gray, moist, fine Silty SAND (SM)	54.0								
60				Very dense, gray, moist fine Silty SAND (SM)									
65		20 18 19	83	Becoming dense with some silt, coarse to fine sand, trace of fine gravel									
70					333.0								
		16	83		74.0								

Completion Depth: 75.5 Ft.

Water Depth: 14 ft., After ATD hrs.

Project No.: 2399STL022

ft., After hrs.

Project Name: Solutia

ft., After hrs.

Drilling Contractor: Redi

Logged by: Tim Hicks

12/2/99 WCCXS TL022

URS Greiner Woodward Clyde

LOG of BORING No. GB-2

DATE 11/9/99 SURFACE ELEVATION, FT 407.0 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLES	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
75		16 13		Becoming medium dense, gray, wet, coarse to fine gravel with medium to fine SAND (SP)	331.5 75.5								
				Bottom of boring at 75.5ft.									
80													
85													
90													
95													

Completion Depth: 75.5 Ft. Water Depth: 14 ft., After ATD hrs.

Project No.: 2399STL022 ft., After hrs.

Project Name: Solutia ft., After hrs.

Drilling Contractor: Redi Logged by: Tim Hicks

12/2/99 WCCXS TL022

URS Greiner Woodward Clyde

Figure A-3

LOG of BORING No. GB-3

DATE 11/10/99 SURFACE ELEVATION, FT 407.5 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
0		83	Medium stiff, dark brown, moist, low plasticity Silty CLAY (CL)	405.5			14 6 9				Boring advanced with 4 1/4in. I.D HSA and Mud Rotary
2.0		63 83	Loose, tan, dry SILT (ML); with some sand and trace of clay	400.5							
7.0			Loose, tan, dry fine SAND (SM); with some silt	398.5			7 6 21				
9.0	6 4 4	94	Loose, brown, moist, fine Sandy SILT (ML/SM) Becoming saturated ▽	396.0			8 35				
11.5	4 2 2	83	Loose, gray, wet SILT (ML); with some sand	393.5			36	32	7		Switched to Mud Rotary
14.0	2 1 3	83	Loose, brown, tan, wet Sandy SILT (ML)	388.5			33				
19.0	7 8 9	83	Medium dense, tan, gray, fine Silty SAND (SM)				27				
	8	83									

Completion Depth: 50.5 Ft. Water Depth: 10.5 ft., After ATD h

Project No.: 2399STL022 ft., After ___ hrs.

Project Name: Solutia ft., After ___ hrs.

Drilling Contractor: Redi Logged by: Tim Hicks

12/2/99 WCCXS TL022

URS Greiner Woodward Clyde

LOG of BORING No. GB-3

DATE 11/10/99 SURFACE ELEVATION, FT 407.5 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLES	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
25		12 14		Medium dense, tan, gray fine SAND (SM)									
30		7 8 9	67										
35		8 10 12	83	Decrease in silt content, becoming trace of silt, and trace ofr medium to fine gravel									
40		11 12 11	72	Decrease in silt content, trace of silt and trace of medium to fine gravel									
45		12 12 12	67	Medium dense, tan, gray, fine SAND (SM)					19				
		5	72										

Completion Depth: 50.5 Ft.
Project No.: 2399STL022
Project Name: Solutia
Drilling Contractor: Redi

Water Depth: 10.5 ft., After ATD hrs.
ft., After hrs.
ft., After hrs.
Logged by: Tim Hicks

12/2/99 WCCXS TL022

URS Greiner Woodward Clyde

LOG of BORING No. GB-3

DATE 11/10/99 SURFACE ELEVATION, FT 407.5 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLES	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
50		11			357.0								
		14		Bottom of boring at 50.5ft.	50.5								
55													
60													
65													
70													

Completion Depth: 50.5 Ft. Water Depth: 10.5 ft., After ATD

Project No.: 2399STL022 ft., After hrs.

Project Name: Solutia ft., After hrs.

Drilling Contractor: Redi Logged by: Tim Hicks

Figure A-4

LOG of BORING No. HA-1

Sheet 1 of 1

DATE 11/15/99 SURFACE ELEVATION, FT 401.0 DATUM USGS LOCATION See Figure 1.

DEPTH, ft.	SAMPLES	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
0				Firm, dark brown, low to medium Silty CLAY (CL)	399.5								
				Loose, tan, fine Sandy SILT ~~(SM)~~ ML; with trace of clay	1.5 399.0								
				Bottom of Hand Auger at 2ft.	2.0								
5													

Completion Depth: 2.0 Ft. Water Depth: ____ ft., After ____ hrs.

Project No.: 2399STL022 ____ ft., After ____ hrs.

Project Name: Solutia ____ ft., After ____ hrs.

Drilling Contractor: Redi Logged by: Tim Hicks

11/19/99 WCCXS TL022

URS Greiner Woodward Clyde

Figure A-5

LOG of BORING No. HA-2

Sheet 1 of 1

DATE 11/15/99 SURFACE ELEVATION, FT 400.0 DATUM USGS LOCATION See Figure 1.

DEPTH, ft.	SAMPLES	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
0				Firm, dark brown, low to medium plasticity Silty CLAY (CL)	398.5								
				Loose, tan, fine Sandy SILT (SM); with trace of clay	1.5 398.0								
				Bottom of Hand Auger at 2ft.	2.0								
5													

Completion Depth: 2.0 Ft. Water Depth: ___ ft., After ___ h

Project No.: 2399STL022 ___ ft., After ___ hrs.

Project Name: Solutia ___ ft., After ___ hrs.

Drilling Contractor: Redi Logged by: Tim Hicks

11/19/99 WCCXS TL022

URS Greiner Woodward Clyde

LOG of BORING No. GB-4

DATE 11/7/00 SURFACE ELEVATION, FT 402.0 DATUM USGS LOCATION

DEPTH, ft.	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
0	P	96	Soft, moist, low plasticity Silty CLAY (CL)	400.7			24 14	37	14		Boring advanced with 4 1/4in. I.D, 9in. O.D HSA
			Very loose, moist, light brown to gray, fine SAND (SP)	1.3 399.6			14				
	P	86	Firm, moist, dark brown Silty CLAY (CL)	2.4 398.0			11 30 27	34	17		
	3	92	Very loose, moist, light brown to gray, Silty SAND (SM)	4.0 397.0							
5			Loose, moist, brownish gray, Sandy SILT (ML)	5.0			21				
	4	83									
			Becomes very loose, wet, light brown								
	2	88									
							35				
10	WH/2	83	Becomes gray								
				390.0							
	WH		Very soft, wet, gray, low plastic Silty CLAY (CL)	12.0 388.1			35	38	21		
	P	67	Loose, wet, gray SILT (ML)	13.9 387.2							
15			Firm, gray, high plastic CLAY (CH)	14.8			26				Clay lens, 10in. thick
	10	75	Medium dense, wet, gray, SILT (CL-ML); trace sand	386.5 15.5							
	7	67		383.5							
			Loose, wet, gray, Silty SAND (SM)	18.5 382.0			27				
20			Bottom of boring at 20ft.	20.0							

Completion Depth: 20.0 Ft.
Water Depth: 15.5 ft., After ATD hrs.
7.1 ft., After 3 hrs.
ft., After hrs.
Project No.: 2399STL022
Project Name: Solutia
Drilling Contractor: Harriss Drilling
Logged by: Martin Swanson

URS Corporation

LOG of BORING No. GB-5

DATE 11/7/00 SURFACE ELEVATION, FT 405.2 DATUM USGS LOCATION ____

DEPTH, ft.	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
0	P	71	Firm, lightly moist, brownish gray, Silty CLAY (CL)	403.2 / 2.0			25, 26, 27, 28	34	12		Boring advanced with 4 1/4in. I.D, 9in O.D HSA
	P	54	Loose, moist, tan SILT (CL-ML); trace sand	401.2 / 4.0			31, 26, 22				
5	6	92	Firm, moist, brown, low plastic CLAY (CL)				29	34	15		
	6	92		397.2 / 8.0			29				
	2	88	Very loose, wet, brown, Sandy SILT (ML)				33				
10	P	0		393.2 / 12.0							No recovery
	7	75	Loose, wet, brown, Silty SAND (SM)	391.2 / 14.0							
15	5	88	Loose, wet, brown, Sandy SILT (ML)	389.2 / 16.0							
	P	92	Loose, wet, brown, Silty SAND (SM)	387.2 / 18.0							
	9	100	Loose, wet, brown, fine SAND (SP)	385.2 / 20.0			25				
20			Bottom of boring at 20ft.								

Completion Depth: 20.0 Ft. Water Depth: 15 ft., After ATD hr

Project No.: 2399STL022 8 ft., After 1

Project Name: Solutia ____ ft., After ____ hrs.

Drilling Contractor: Harriss Drilling Logged by: Martin Swanson

12/15/00 WCCXS TL022

URS Corporation

Figure A-8

LOG of BORING No. PZ-1

DATE 11/8/99 SURFACE ELEVATION, FT 402.0 DATUM USGS LOCATION See Figure 1

DEPTH, ft.	SAMPLING RESISTANCE	RECOVERY, %	DESCRIPTION	STRATUM EL / DEPTH	PP, TSF	FIELD Qu,KSF	NMC, %	LL	PI	Qu, KSF	NOTES
0			Soft, moist, brown,low plasticity Silty CLAY								Boring advanced with 4 1/4in. I.D HSA
	2 4 5	100	Becoming stiff				31				
5	2 3 3	100	Becoming firm, medium plasticity mottled brown, gray		1.5		36	60	40		
	1 1 2	100		394.8							
			Very loose, wet, gray, Sandy SILT (ML); with medium to fine sand	7.2			36				
				392.5							
10			Loose, wet, gray, medium to fine SAND (SM); with some silt	9.5							
15	1 0 1	78	Very loose, wet, tan, fine SAND (SM); with a trace of silt								
20	8 9 10	88	Becoming medium dense	381.5							
			Bottom of boring at 20.5ft.	20.5							

Completion Depth: 20.5 Ft. Water Depth: 9.5 ft., After ATD hrs.

Project No.: 2399STL022 10 ft., After 18 hrs.

Project Name: Solutia ft., After hrs.

Drilling Contractor: Redi Logged by: Tim Hicks

12/2/99 WCCXS TL022

URS Greiner Woodward Clyde

MONITORING WELL INSTALLATION REPORT

Well No. PZ-1

Project Solutia

Location See Figure 1.

Project No 2399STL022 Installed By Redi Date 11/8/99 Time 1100

Method of Installation 4 1/4in. H.S.A. Done 1150

LOG OF BORING AND WELL

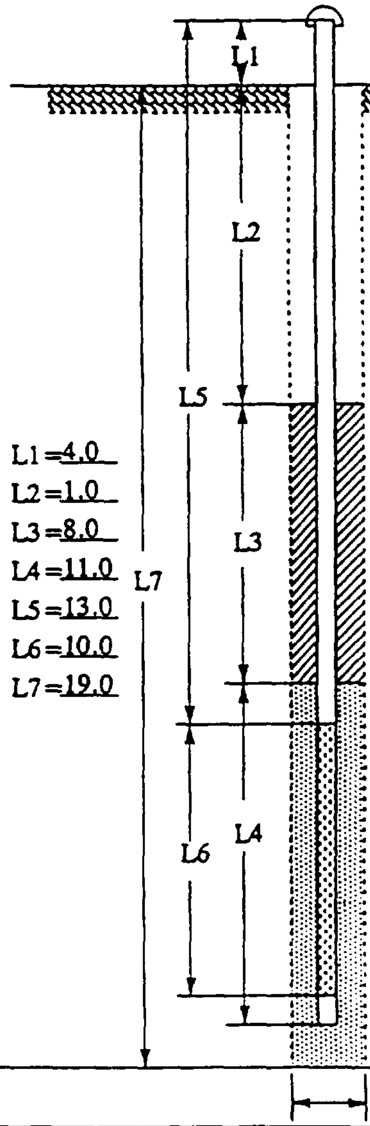
BORING

Depth In Ft.	Description	Symbol
0.00	Soft, moist, brown, low plasticity Silty CLAY Becoming stiff Becoming firm, medium plasticity mottled brown, gray	
7.20	Very loose, wet, gray, Sandy SILT (ML); with medium to fine sand	
9.50	Loose, wet, gray, medium to fine SAND (SM); with some silt Very loose, wet, tan, fine SAND (SM); with a trace of silt Becoming medium dense	
	Bottom of boring at 20.5ft.	

WELL

Type of Well

Ground Elev. 401.8 Top of Riser Elev. 405.8



L1 = 4.0
L2 = 1.0
L3 = 8.0
L4 = 11.0
L5 = 13.0
L6 = 10.0
L7 = 19.0

Riser Pipe I.D., in. 1in.

Type of Pipe PVC

Backfill Type Around Riser Portland cement

Top of Seal Elevation

Type of Seal Material See below

Top of Filter Elevation 8.0

Type of Filter Material Quartz

Size of Opening, in. 0.01

Diameter of Well Tip, in. 1.0

Bottom of Screen Elevation 19.0

Bottom of Riser Elevation 19.0

Bttm of Boring Elev. 19.0

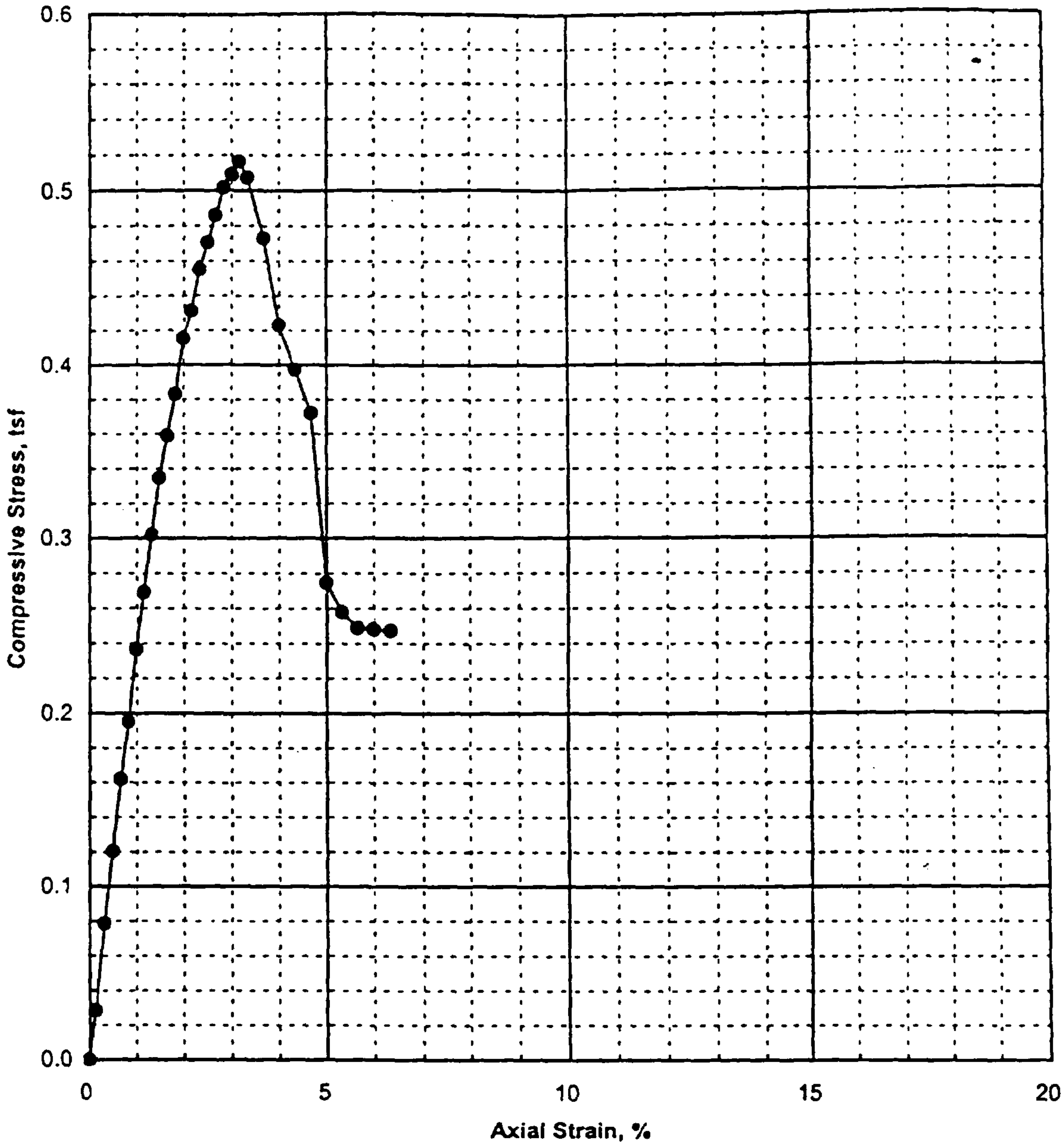
Diameter of Boring, in. 4.2

Remarks

Inspected By Tim Hicks

WOODWARD-CLYDE CONSULTANTS

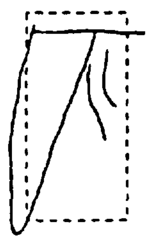
Subsurface Soil Laboratory Test Data



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	LL	PI	Length (in)	Diameter (in)
20.4	106.3	88.4			2.959	1.886

Description and/or Classification: ML, brown slightly to nonplastic SILT, trace f. sand



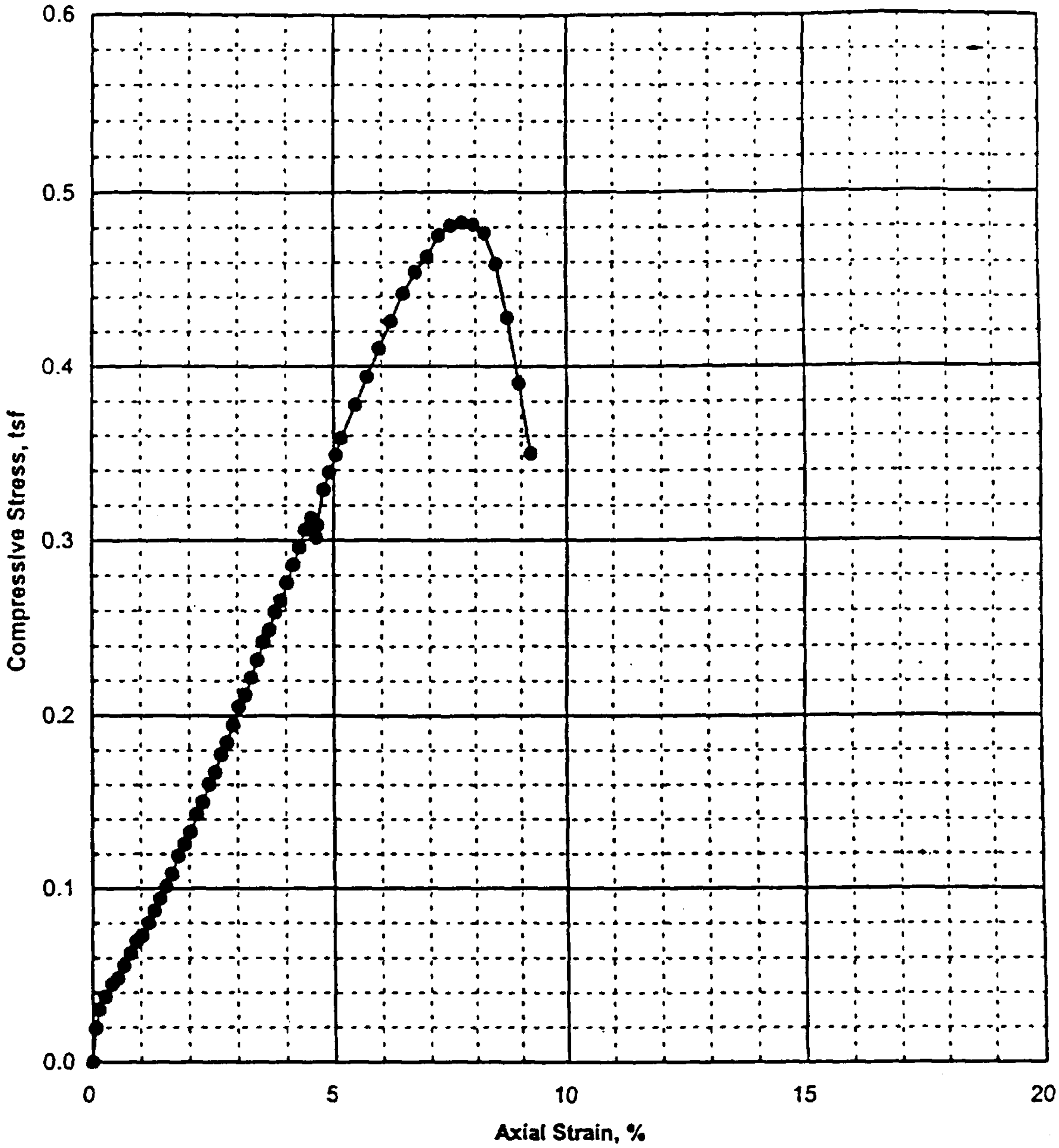
FAILURE SKETCH

Tested by: BB
Test Date: Nov-18-99
Reviewed by: MM

Test Summary

q_u (tsf)	Strain to Peak (%)	Strain Rate (%/min)
0.52	3.16	1.00

Project No.	SOLUTIA	UNCONFINED COMPRESSION TEST	
23-99STL0022.01		Boring: GB-1	
URS Greiner Woodward Clyde		Sample: A Depth:4.35-4.7	November 1999



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	LL	PI	Length (in)	Diameter (in)
28.2	115.0	89.7			5.862	2.874

Description and/or Classification: ML, brown slightly to nonplastic SILT, trace f. sand

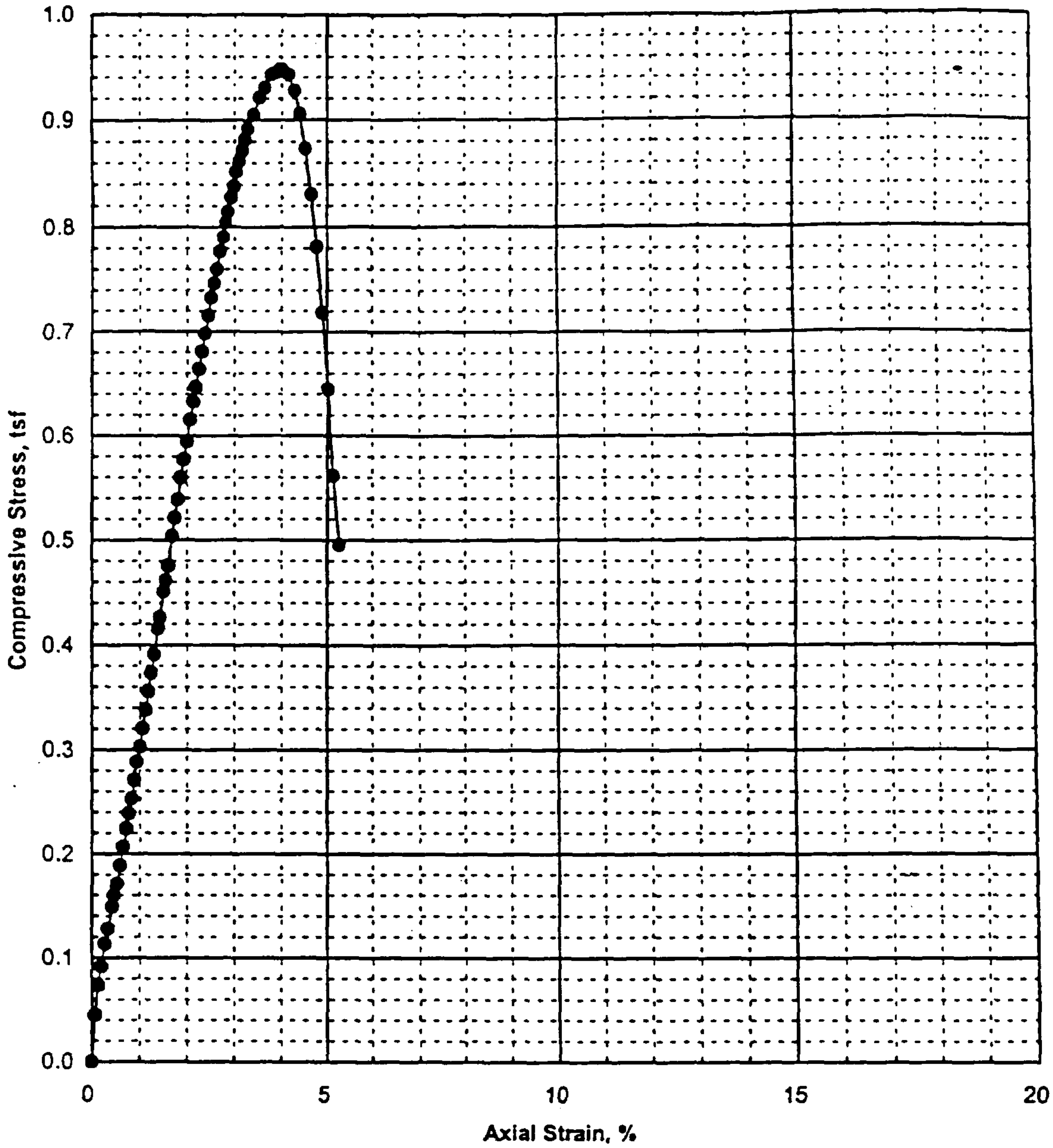
FAILURE SKETCH

Tested by: BB
Test Date: Nov-17-99
Reviewed by: [signature]

Test Summary

q_u (tsf)	Strain to Peak (%)	Strain Rate (%/min)
0.48	7.70	0.74

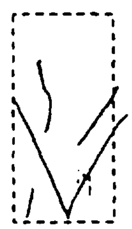
Project No. 23-99STL0022.01	SOLUTIA	UNCONFINED COMPRESSION TEST Boring: GB-1 Sample: A Depth:6.45	
URS Greiner Woodward Clyde			November 1999



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	LL	PI	Length (in)	Diameter (in)
22.6	116.0	94.7			6.006	2.873

Description and/or Classification: ML, light brown s-np SILT, trace clay; top 1" CL, dark brown silty CLAY.



FAILURE SKETCH

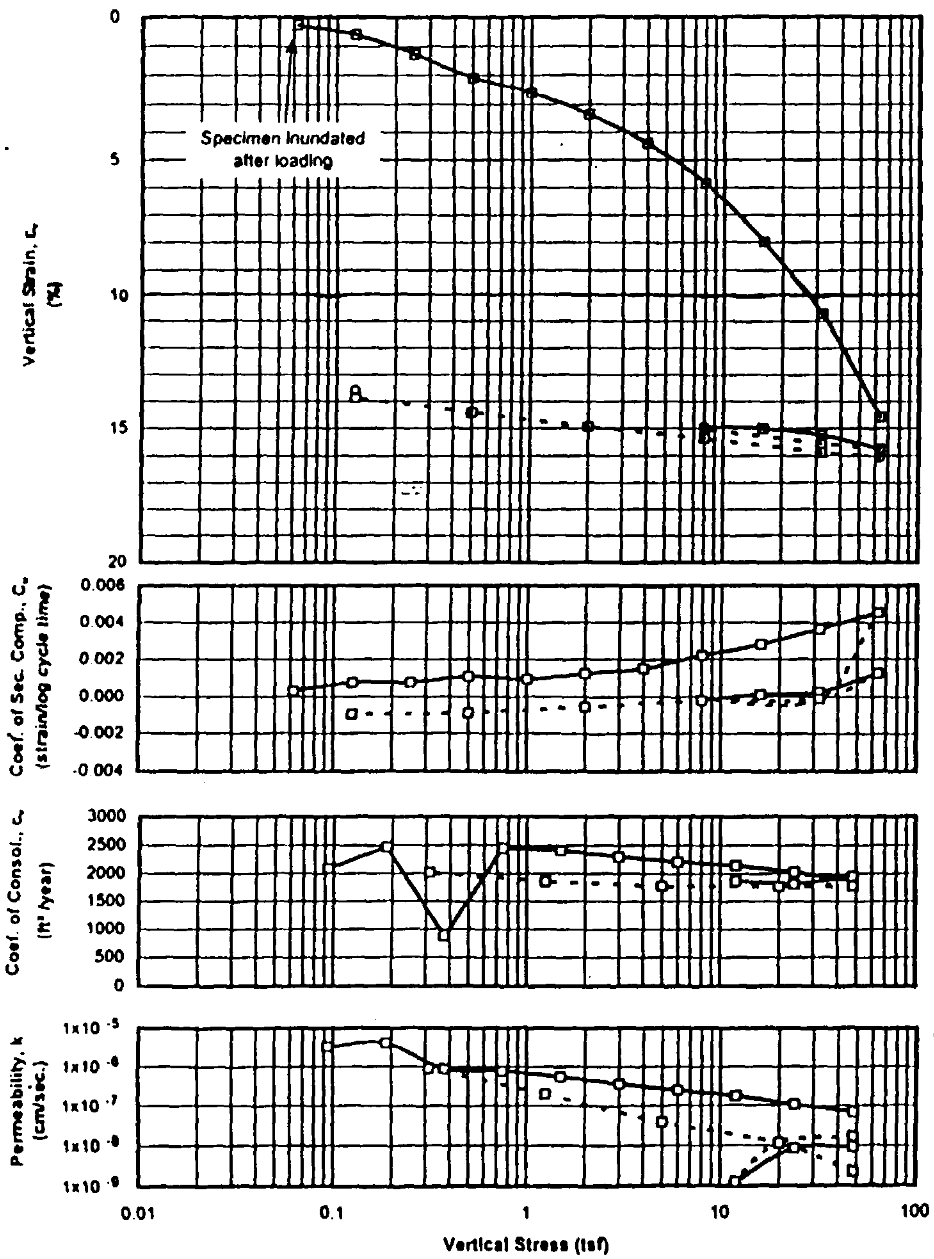
Tested by: BB
Test Date: Nov-29-99
Reviewed by: 91

Test Summary

q_u (tsf)	Strain to Peak (%)	Strain Rate (%/min)
0.95	3.96	0.73

Project No. 23-99STL0022.01	SOLUTIA	UNCONFINED COMPRESSION TEST Boring: GB-2	
URS Greiner Woodward Clyde		Sample: A Depth:1.35	November 1999

Figure A-13



SAMPLE INFORMATION

Boring:	GB-1
Sample:	Spec C
Depth:	7.55 feet
Elevation:	
Type:	3-inch thin wall tube
	ML, brown nonplastic SILT, trace f. sand

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.61	inch
Diameter:	2.50	inch

Initial water content:	32.3	%	
Initial total unit weight:	113.9	pcf	
Initial dry unit weight:	86.1	pcf	
Initial void ratio:	1.000		
Initial degree of saturation:	89	%	
Final water content:	29.6	%	
Final total unit weight:	122.9	pcf	
Final dry unit weight:	94.8	pcf	
Final void ratio:	0.818		
Final degree of saturation:	100	%	(assumed specific gravity = 2.76)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	12.8 (Range: 10.9 to 15.3)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.128
Compression Index (void ratio per log cycle stress):	0.256
Swell Ratio (strain per log cycle stress):	0.008
Swell Index (void ratio per log cycle stress):	0.016
Recompression Ratio (strain per log cycle stress):	0.012
Recompression Index (void ratio per log cycle stress):	0.024
Remarks:	

LEGEND: □ End of primary ○ End of Stage ——— Loading - - - - - - Unloading

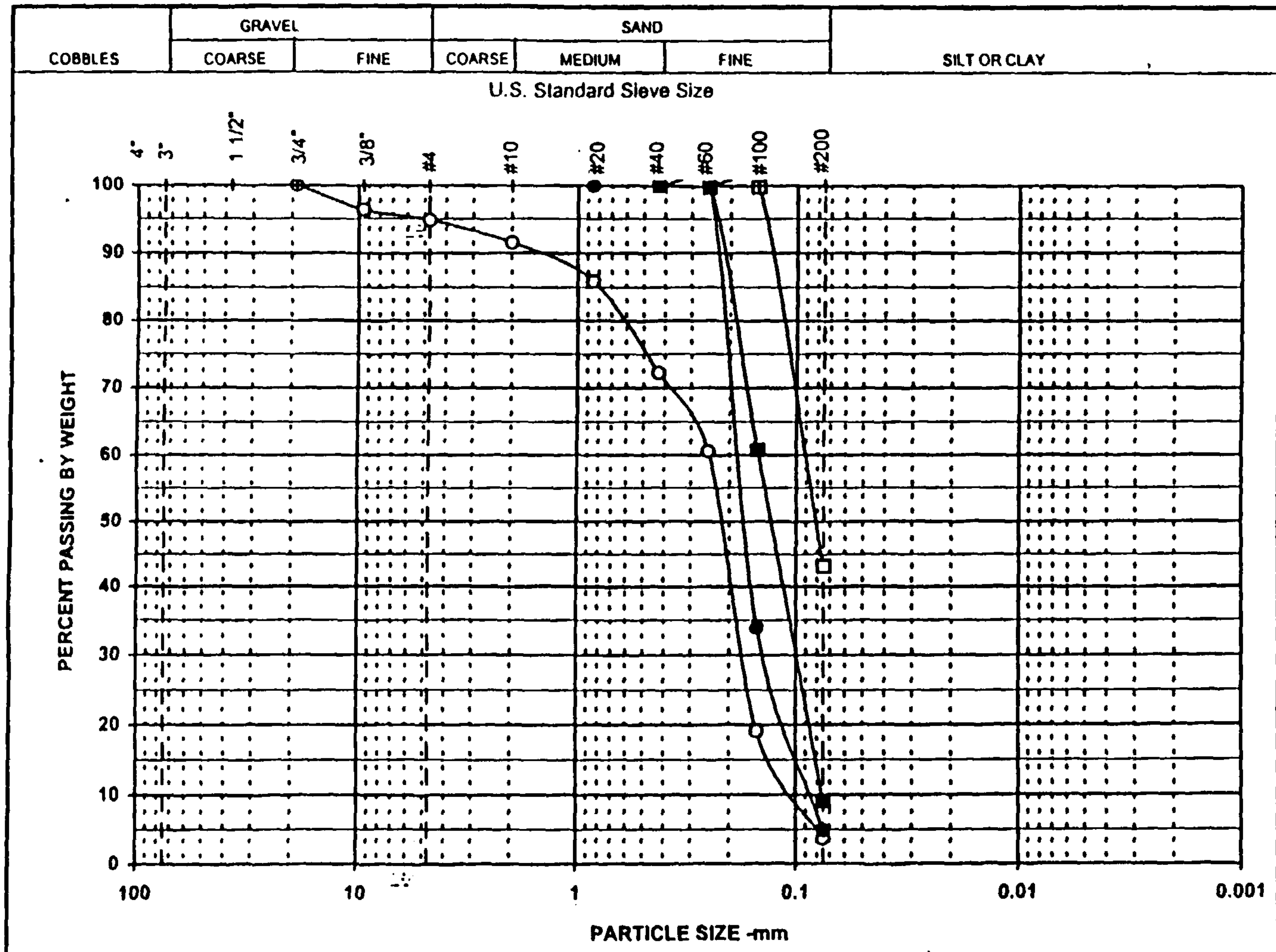
Test Date: 11/17/99 Tested By: GET Checked By:

	Solutia	ONE DIMENSIONAL CONSOLIDATION TEST Boring: GB-1 Depth: 7.55 feet
URS Greiner Woodward Clyde	Project No. 23-99STL0022	November 1999 Fig.

GSI Analysis File: Conv30.xls

C99212

Figure



Symbol	□	■	○	●
Boring	GB-1	GB-2	GB-2	GB-3
Sample				
Spec				
Depth	14-15.5	9-10.5	29-30.5	19-20.5
% +3"				
% Gravel			5.2	
% SAND	56.8	90.9	91.1	95.2
% FINES	43.2	9.1	3.7	4.8
% -2μ				
Cc		1.0	1.2	1.2
Cu		2.0	2.3	2.1
LL				
PL				
PI				
USCS	SM	SP-SM	SP	SP
w (%)	36.6	25.5	22.1	26.9

Particle Size (Sieve #)	PERCENT FINER □	■	○	●
4"				
3"				
1 1/2"				
3/4"			100.0	
3/8"			96.3	
4			94.8	
10			91.5	
20			85.9	100.0
40	100.0	100.0	72.2	99.9
60	99.9	99.8	60.6	99.7
100	99.8	60.7	19.1	33.9
200	43.2	9.1	3.7	4.8

SYMBOL	DESCRIPTION AND REMARKS
□	dark brown silty f. SAND.
■	brown f. SAND, trace silt.
○	dark brown m-f SAND, trace gravel, c. sand, silt.
●	brown f. SAND, trace silt.

PARTICLE SIZE DISTRIBUTION
Solutia

Project No.		
23-99STL022	November 1999	Figure

URS Greiner Woodward Clyde

PROJECT:	Solutia				
PROJECT NO.:	23-99STL0022	Initial height:	0.613 inch	Final height:	0.554 inch
BORING:	GB-1	Initial water content:	32.3 %	Final water content:	29.6 %
SAMPLE:	Spec C	Initial dry density:	86.1 pcf	Final dry density:	94.8 pcf
TEST:	C99216	Initial total density:	113.9 pcf	Final total density:	122.9 pcf
DEPTH, feet:	7.55	Initial saturation:	89 %	Final saturation:	100 %
BY:	GET	Initial void ratio:	1.000	Final void ratio:	0.818
TEST DATE:	11/17/1999			Final strain:	9.8 %

EQUIPMENT:
Load Frame No.: 5
Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: ML, brown nonplastic SILT, trace f. sand

G	LL	PL	PI
2.76		np	

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft²/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.063	0.0017	0.277	0.995	0.345	0.994	89.22	0.0003	22.56	1.19E-07
2	0.125	0.0037	0.602	0.988	0.857	0.983	2086.38	0.0007	19.26	3.27E-06
3	0.250	0.0078	1.273	0.975	1.511	0.970	2467.32	0.0008	18.63	4.00E-06
4	0.500	0.0128	2.093	0.959	2.371	0.953	871.77	0.0011	30.47	8.63E-07
5	1.00	0.0160	2.610	0.948	2.905	0.942	2440.00	0.0009	96.78	7.61E-07
6	2.00	0.0206	3.359	0.933	3.832	0.924	2407.63	0.0012	133.40	5.44E-07
7	4.00	0.0271	4.410	0.912	4.911	0.902	2301.41	0.0015	190.31	3.65E-07
8	8.00	0.0360	5.862	0.883	6.533	0.870	2207.57	0.0022	275.50	2.42E-07
9	16.0	0.0490	7.994	0.841	9.213	0.816	2144.66	0.0028	375.26	1.72E-07
10	32.0	0.0657	10.708	0.786	11.603	0.768	2031.05	0.0036	589.49	1.04E-07
11	64.0	0.0893	14.564	0.709	15.759	0.685	1871.59	0.0046	829.93	6.80E-08
12	32.0	0.0955	15.562	0.689	15.531	0.690	1796.95	-0.0001	3208	1.69E-08
13	8.00	0.0922	15.023	0.700	14.940	0.702	1771.15	-0.0002	4455	1.20E-08
14	16.0	0.0920	15.005	0.700	15.050	0.699	1868.95	0.0001	45734	1.23E-09
15	32.0	0.0936	15.254	0.695	15.314	0.694	1809.76	0.0002	6429	8.49E-09
16	64.0	0.0966	15.751	0.685	16.073	0.679	1950.94	0.0013	6443	9.14E-09
17	32.0	0.0974	15.884	0.683	15.856	0.683	1778.30	-0.0001	24135	2.22E-09
18	8.00	0.0943	15.367	0.693	15.306	0.694	1775.23	-0.0002	4647	1.15E-08
19	2.00	0.0916	14.938	0.702	14.766	0.705	1778.33	-0.0006	1400	3.83E-08
20	0.500	0.0884	14.412	0.712	14.070	0.719	1855.80	-0.0009	285.14	1.96E-07
21	0.125	0.0850	13.863	0.723	13.580	0.729	2015.63	-0.0009	68.20	8.92E-07

Solu..., Cahokia

LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS									STRENGTH			CONSOL.		REMARKS
			WATER	LIQUID	PLASTIC	PLAS.	USCS	SIEVE	HYDRO.	TOTAL	SPECIFIC	UU	PEAK	AXIAL STRAIN	INITIAL CONDITIONS		
NO.	NO.		CONTENT	LIMIT	LIMIT	IND.	SYMB.	MINUS	% MINUS	UNIT	GRAVITY	CELL	DEVIATOR	@ PEAK	VOID	SATUR-	
							(1)	NO. 200	2 μm	WEIGHT		PRESSURE	STRESS	STRESS	RATIO	ATION	
		(ft)	(%)					(%)	(%)	(pcf)		(tsf)	(tsf)	(%)			
GB-4	S-1	0-2								101.8							
GB-4	S-1A	0.5	23.6	37	14	23	CL	65.3	21	113.1	2.654	0.5	0.8	15.6			
GB-4	S-1	1.2	14.4				SM										
GB-4	S-1C	1.55	14.1				SP			100.3							perm.
GB-4	S-2	2-4								104.1							
GB-4	S-2	2.45	10.7				CL										
GB-4	S-2	3	30.4				CL										
GB-4	S-2B	3.25	26.9	34	19	15	CL	84.7	17								
GB-4	S-3	4-6	21.3	np	np	np	ML	58.9	5								
GB-4	S-4	6-8					ML										visual
GB-4	S-5	8-10	34.6	np	np	np	ML	72.0	5		2.660						
GB-4	S-6	10-12					ML										visual
GB-4	S-7	12-14	35.3	38	21	17	CL	99.4	16								
GB-4	S-8	14-16	25.8	np	np	np	ML	96.1	10								
GB-4	S-9	16-18					CL-ML	92.9	16								
GB-4	S-10	18-20	27.1				SM	18.6			2.672						

Prepared by: RR Reviewed by: JJ Date: 12/12/2000

Solutia, Cahokia

LABORATORY TESTING DATA SUMMARY

BORING	SAMPLE	DEPTH	IDENTIFICATION TESTS									STRENGTH			CONSOL.		REMARKS
															INITIAL CONDITIONS		
NO.	NO.	(ft)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLAS. IND.	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	HYDRO. % MINUS 2 μm (%)	TOTAL UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	UU CELL PRESSURE (tsf)	PEAK DEVIATOR STRESS (tsf)	AXIAL STRAIN @ PEAK STRESS (%)	VOID RATIO	SATUR-ATION	
GB-5	S-1	0-2								112.1							
GB-5	S-1	0.15	25.1														
GB-5	S-1A	0.4	26.4				CL	90.1	21	112.3		1.0	0.9	15.5			
GB-5	S-1	0.7	27.4				CL										
GB-5	S-1B	0.95	28.1	36	24	12	CL			114.2	2.670				0.856	87	
GB-5	S-2	2-4								111.1							
GB-5	S-2	2.15	30.7				CL-ML										
GB-5	S-2A	2.45	25.5				CL-ML	95.1									
GB-5	S-2	2.65	22.1				CL-ML										
GB-5	S-3	4-6	29.1	34	22	12	CL	98.0	13								
GB-5	S-4	6-8	29.4														
GB-5	S-5	8-10	33.1				ML	55.2									
GB-5	S-6	10-12															no sample
GB-5	S-7	12-14					SM	42.6	5								
GB-5	S-8	14-16					ML										visual
GB-5	S-9	16-18					SM	46.5	4								
GB-5	S-10	18-20	25.3				SP	3.3									

Note: (1) Plasticity of fines for USCS symbol based on visual observation unless Sieve and Atterberg limits reported.

Prepared by: RR Reviewed by: JH Date: 12/12/2000

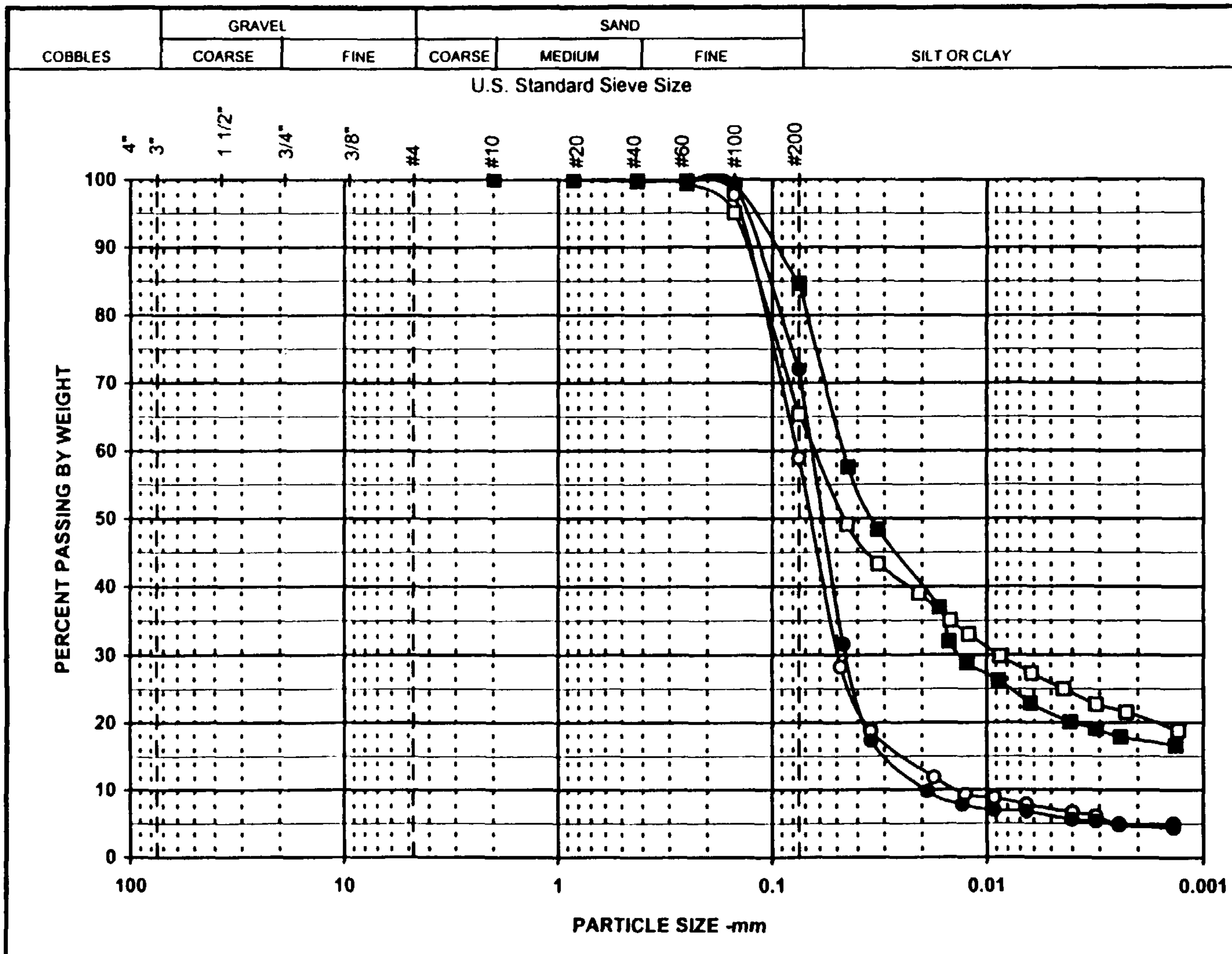
Project No.: 23-99STL022.01 File: Visual2.xls

Figure A-18

Solutia, Cahokia
VISUAL CLASSIFICATION

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL DESCRIPTION	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	POCKET PEN. (tsf)
GB-4	S-4	6-8	ML, brown non-plastic SILT, trace f. sand.				
GB-4	S-6	10-12	ML, light gray non-plastic SILT, trace f. sand.				
GB-5	S-8	14-16	ML, light gray non-plastic SILT, trace f. sand.				

Prepared by: RR Reviewed by: UMO Date: 11/28/2000



Symbol	□	■	○	●
Boring	GB-4	GB -4	GB-4	GB-4
Sample	S-1	S-2	S-3	S-5
Spec	A	B		
Depth	0.5	3.25	4-6	8-10
% +3"				
% Gravel				
% SAND	34.7	15.3	41.1	28.0
% FINES	65.3	84.7	58.9	72.0
% -2μ	21	17	5	5
Cc				
Cu				
LL	37	34		
PL	14	19	np	np
PI	23	15		
USCS	CL	CL	ML	ML
w (%)	23.6			

Particle Size (Sieve #)	PERCENT FINER □	■	○	●
4"				
3"				
1 1/2"				
3/4"				
3/8"				
4				
10	100.0			
20	99.9	100.0	100.0	
40	99.7	99.9	99.9	100.0
60	99.3	99.9	99.8	99.9
100	95.1	99.3	97.7	99.4
200	65.3	84.7	58.9	72.0

SYMBOL	DESCRIPTION AND REMARKS
□	brown f. sandy CLAY.
■	brown silty CLAY, some f. sand.
○	brown f. sandy SILT.
●	brown SILT, some f. sand.

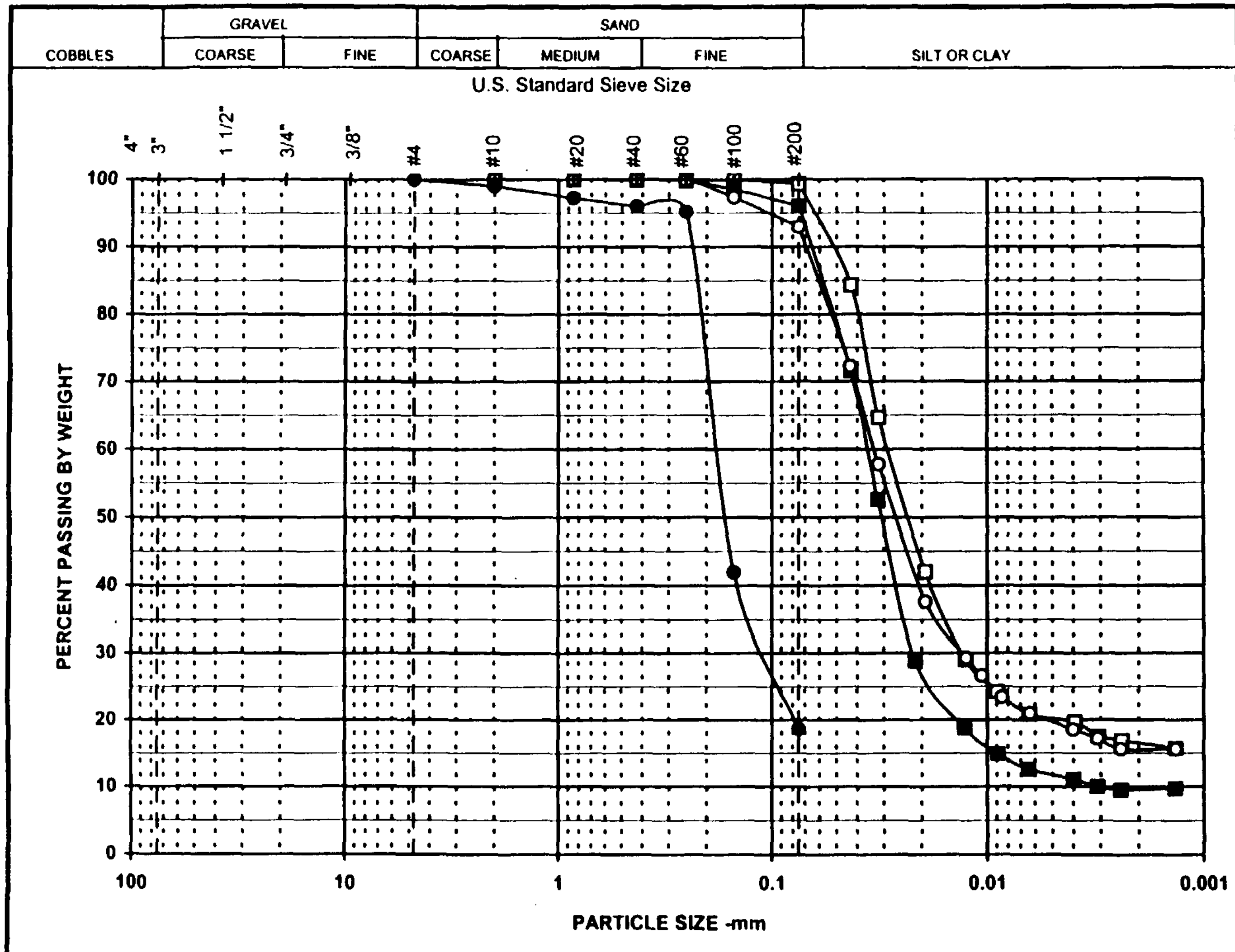
PARTICLE SIZE DISTRIBUTION

Solutia, Cahokia

Project No. 23-99STL022	November 2000	Figure

URS

Figure



Symbol	□	■	○	●
Boring	GB-4	GB -4	GB-4	GB-4
Sample	S-7	S-8	S-9	S-10
Spec				
Depth	12-14	14-16	16-18	18-20
% +3"				
% Gravel				
% SAND	0.6	3.9	7.1	81.4
% FINES	99.4	96.1	92.9	18.6
% -2μ	16	10	16	
Cc				
Cu				
LL	38			
PL	21	np		
PI	17			
USCS	CL	ML	CL-ML	SM
w (%)				27.1

Particle Size (Sieve #)	PERCENT FINER □	■	○	●
4"				
3"				
1 1/2"				
3/4"				
3/8"				
4				100.0
10		100.0		98.9
20	100.0	99.9	100.0	97.2
40	99.9	99.9	99.9	96.0
60	99.9	99.8	99.8	95.2
100	99.9	98.5	97.3	42.0
200	99.4	96.1	92.9	18.6

SYMBOL	DESCRIPTION AND REMARKS
□	gray silty CLAY.
■	gray SILT, trace f. sand.
○	gray silty CLAY, trace f. sand.
●	gray-brown f. SAND, some silt, trace c-m sand.

PARTICLE SIZE DISTRIBUTION

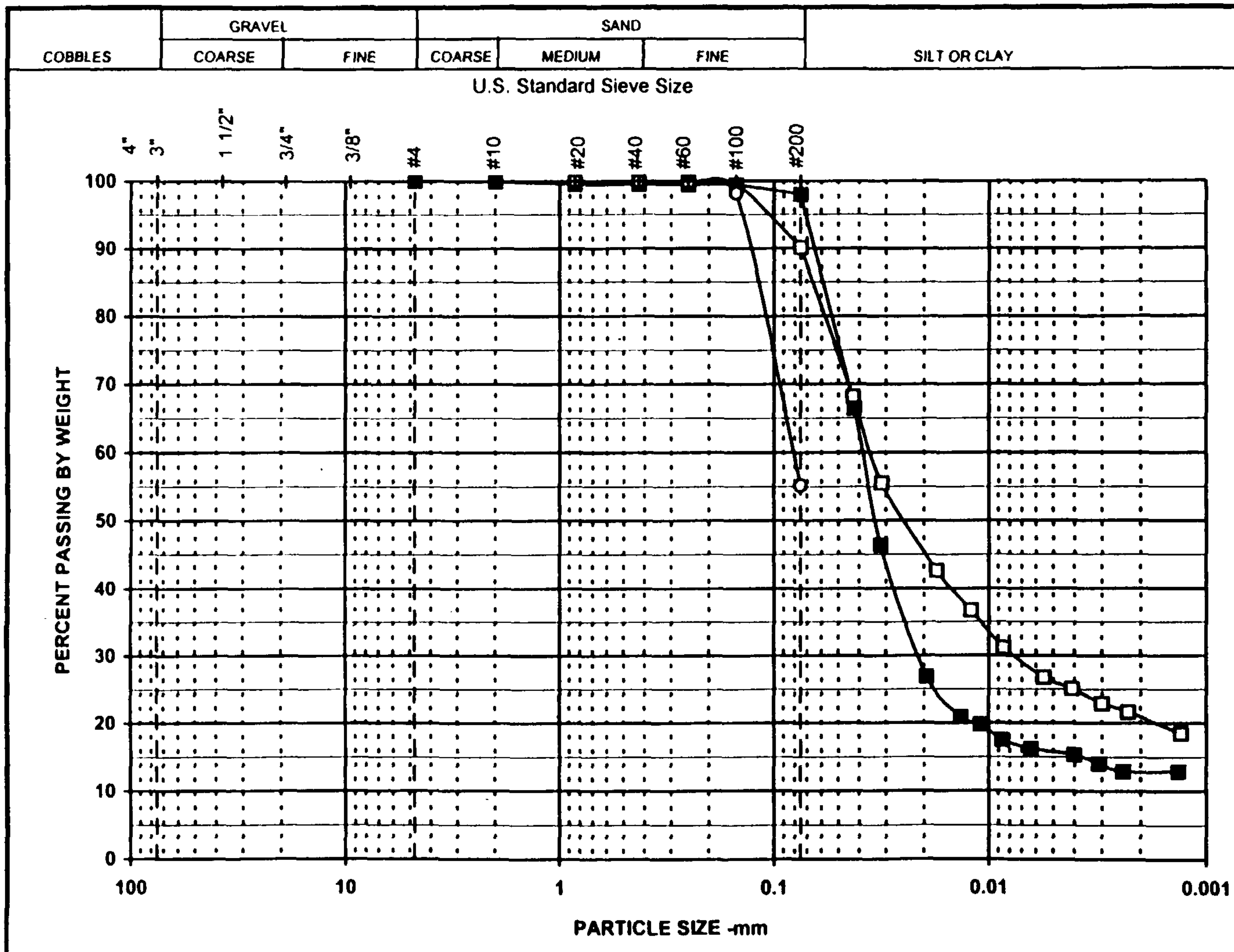
Solutia, Cahokia

Project No. 23-99STL022	November 2000	Figure

URS

Siev2b.xls 11/28/2000

Figure A-21



SYMBOL	DESCRIPTION AND REMARKS
□	dark brown silty CLAY, trace f. sand; fibers noted.
■	brown silty CLAY, trace f. sand.
○	brown f. sandy SILT

Symbol	□	■	○
Boring	GB-5	GB-5	GB-5
Sample	S-1	S-3	S-5
Spec	A		
Depth	0.4	4-6	8-10
% +3"			
% Gravel			
% SAND	9.9	2.0	44.8
% FINES	90.1	98.0	55.2
% -2μ	21	13	
Cc			
Cu			
LL		34	
PL		22	
PI		12	
USCS	CL	CL	ML
w (%)			33.1

Particle Size (Sieve #)	PERCENT FINER □	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4		100.0	
10	100.0	99.9	
20	100.0	99.5	100.0
40	99.9	99.5	99.9
60	99.9	99.4	99.8
100	99.5	99.4	98.2
200	90.1	98.0	55.2

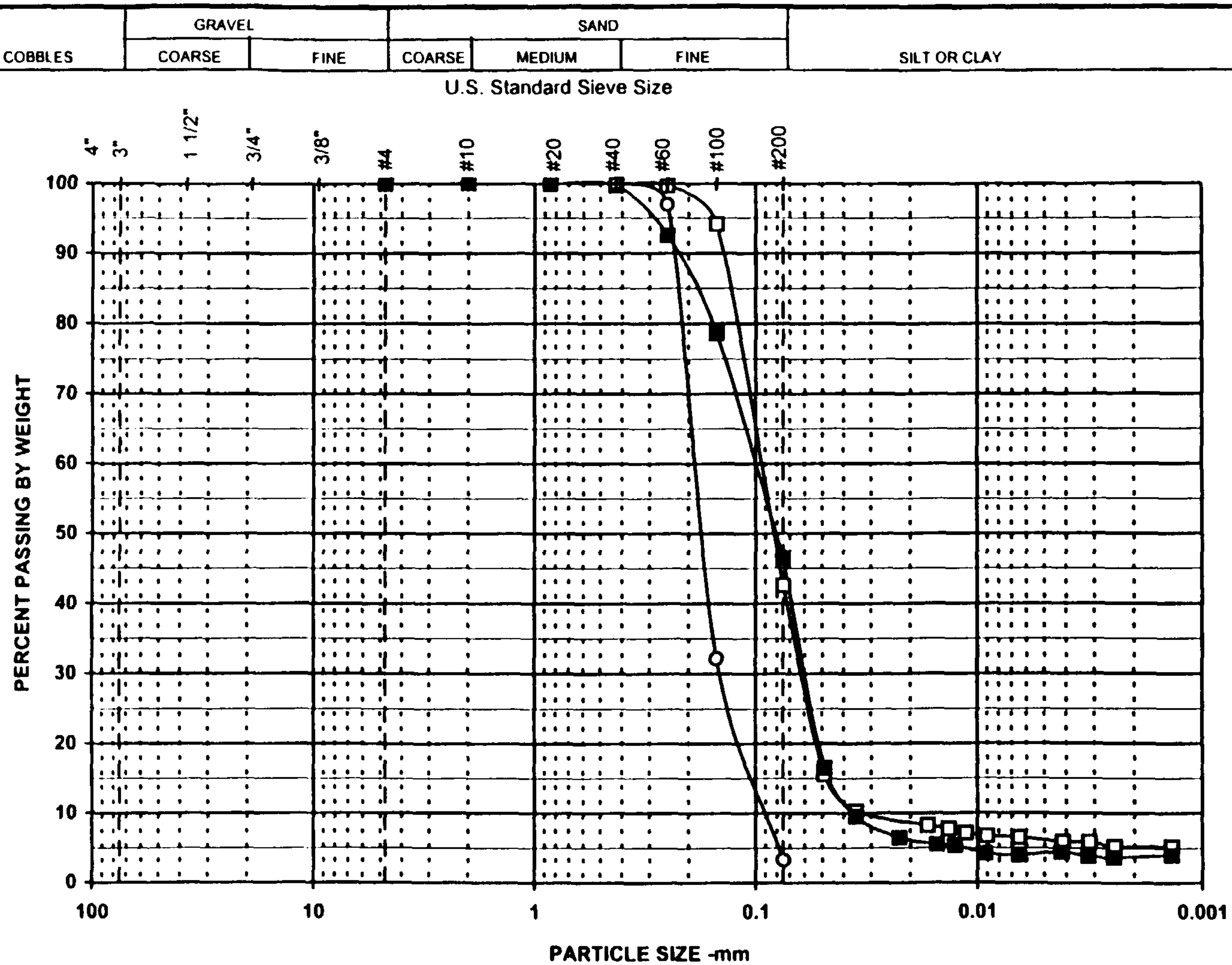
PARTICLE SIZE DISTRIBUTION
Solutia, Cahokia

Project No. 23-99STL022	November 2000	Figure

URS

Siev2c.xls

Figure A



Symbol	□	■	○
Boring	GB-5	GB-5	GB-5
Sample	S-7	S-9	S-10
Spec			
Depth	12-14	16-18	18-20
% +3"			
% Gravel			
% SAND	57.4	53.5	96.7
% FINES	42.6	46.5	3.3
% -2μ	5	4	
Cc			1.2
Cu			2.1
LL			
PL			
PI			
USCS	SM	SM	SP
w (%)			25.3

Particle Size (Sieve #)	PERCENT FINER □	■	○
4"			
3"			
1 1/2"			
3/4"			
3/8"			
4			
10			
20	100.0	100.0	
40	99.9	99.7	100.0
60	99.7	92.6	97.0
100	94.1	78.7	32.1
200	42.6	46.5	3.3

SYMBOL	DESCRIPTION AND REMARKS
□	brown silty f. SAND.
■	brown silty f. SAND.
○	brown f. SAND, trace silt.

PARTICLE SIZE DISTRIBUTION
Solutia, Cahokia

Project No. 23-99STL022	November 2000	Figure

URS

Siev2d.xls 11/28/2000

CONSTANT HEAD HYDRAULIC CONDUCTIVITY TEST
ASTM D 5084 - 90

Project No. 23-99TL022.01 BORING: GP-4
Project Name: Solutia, Cahokia SAMPLE: S-1C DEPTH (ft): 1.55 Test No.: P5973

Specimen - Apparatus set-up - Test Information Apparatus No. C-2 Cell No. 1 Stage 2

1) Specimen Tested in :	x	Triaxial Cell or		Compaction Mold or		
		with stones or		Stones with filter paper or		top + bottom
2) Specimen orientation for:	x	Vertical or		Horizontal permeability determination		
3) During saturation: Water flushed up sides of specimen to remove air:					x No	Yes
4) During consolidation:	x	Top and bottom drainage or			Top	Bottom only
5) Direction of permeant :	x	Up during or		Down during permeation		
6) Permeant: water used	x	Tap		Distilled		
		Demineralized		0.005 N calcium sulfate (CaSO4)		

Consol Stage-Trial No.	Temp. °C	Date	Time hr	min	sec	Initial σ_c psi	Ub psi	Dial Indicator in	Pressure Head Reading Mercury (inch)	Gage (psi)	Flow Reading (cm)	Flow Vol (cm3) Rate (cm3/sec)	Fluid Head Reading Head (cm)	Tail (cm)	Total Head Uncorrected Correction Corrected (cm)	Gradient	Permeability Preliminary Final at 20°C cm/sec
initial	22.0	11/15/00	11	28	00	105.0	100.0	0.522			4.00	76.516	63.45	37.10	26.35		
final	22.0	11/15/00	11	42	31						7.70	0.0878	63.45	37.10	11.61		1.48E-03
1	RT = 0.952	dT =		14.52 min		σ'_c =	0.7 ksf						63.45	37.1	14.74	1.46	1.42E-03
initial	22.0	11/15/00	11	43	00	105.0	100.0	0.522			3.10	64.108	63.45	37.10	26.35		
final	22.0	11/15/00	11	57	34						6.20	0.0734	63.45	37.10	11.24		1.21E-03
2	RT = 0.952	dT =		14.57 min		σ'_c =	0.7 ksf						63.45	37.1	15.11	1.50	1.16E-03
initial	22.0	11/15/00	11	58	45	105.0	100.0	0.522			3.10	179.916	63.45	37.10	26.35		
final	22.0	11/15/00	12	33	00						11.80	0.0876	63.45	37.10	11.57		1.47E-03
3	RT = 0.952	dT =		34.25 min		σ'_c =	0.7 ksf						63.45	37.1	14.78	1.46	1.41E-03
initial	22.0	11/15/00	12	35	00	105.0	100.0	0.522			3.70	74.448	63.45	37.10	26.35		
final	22.0	11/15/00	12	49	40						7.30	0.0846	63.45	37.10	11.18		1.39E-03
4	RT = 0.952	dT =		14.67 min		σ'_c =	0.7 ksf						63.45	37.1	15.17	1.50	1.33E-03

Preliminary Length/Area Calculations

Lo =	3.997	in	Lo=	10.153	cm
Ao=	6.357	in^2	Ao =	41.01	cm^2
Vo=	25.410	in^3	Vo =	416.40	cm^3
Lc =	10.097	cm	Vc =	409.53	cm^3
Ac=	40.559	cm^2			

Tested By: DT Reviewed By: G. Thomas

TEST SUMMARY
Final Specimen and Test Conditions

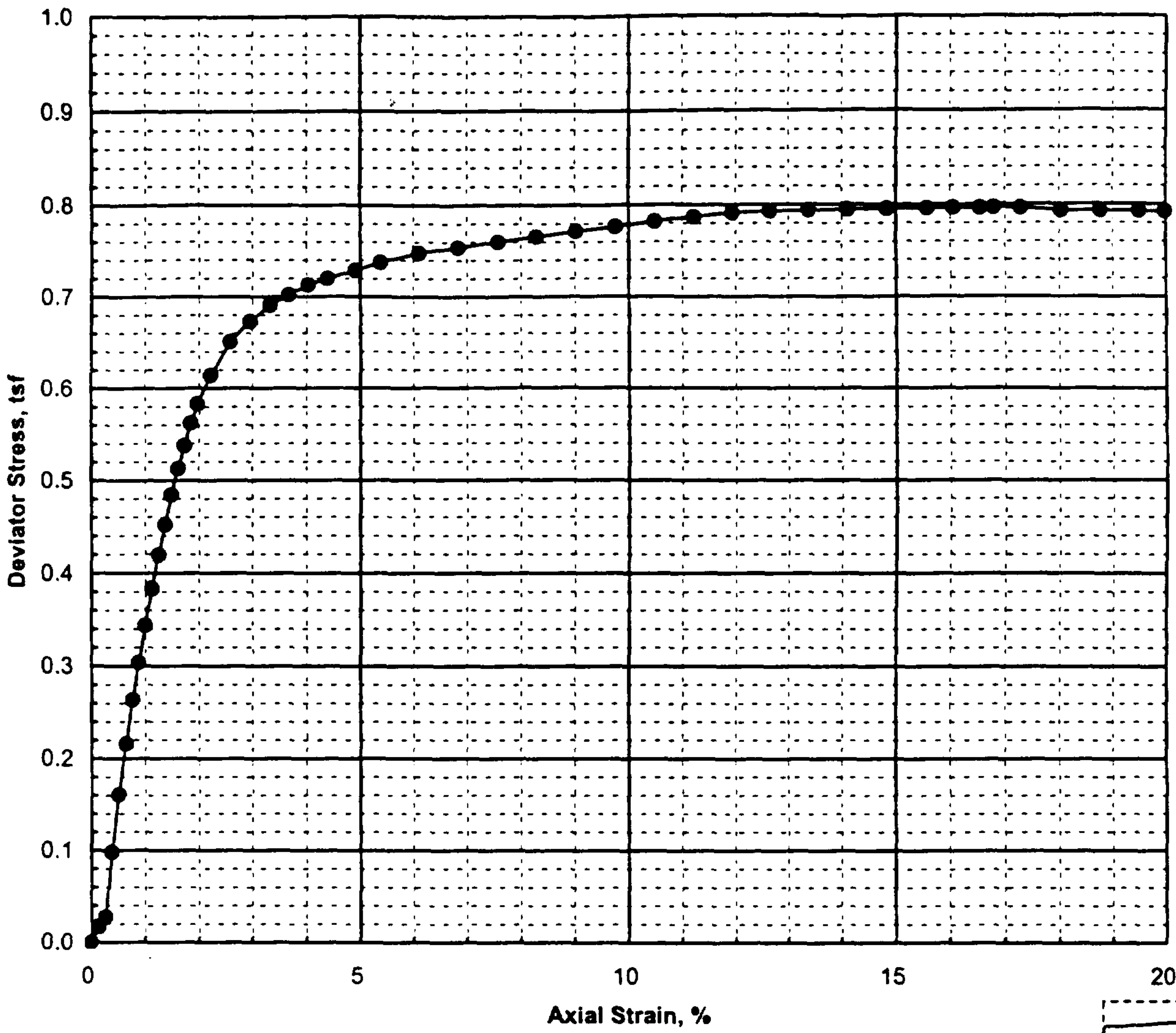
Lc = 10.097 cm ε_{axial} = 0.6%
Ac = 40.347 cm^2
Vc= 407.38 cm^3 ε_{vol} = 2.2%

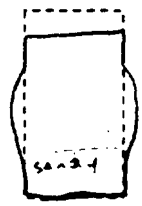
	w (%)	γ_t (pcf)	γ_d (pcf)	S (%)
Initial	14.13	100.3	87.9	41.9
PreTest	32.16	118.8	89.9	100.0

HYDRAULIC CONDUCTIVITY SUMMARY

Averages for trials: 1-4
ave K @ 20 °C: **1.33E-03** cm/sec
(i_o)ave = 1.48

HYDRAULIC CONDUCTIVITY TEST





Specimen Information

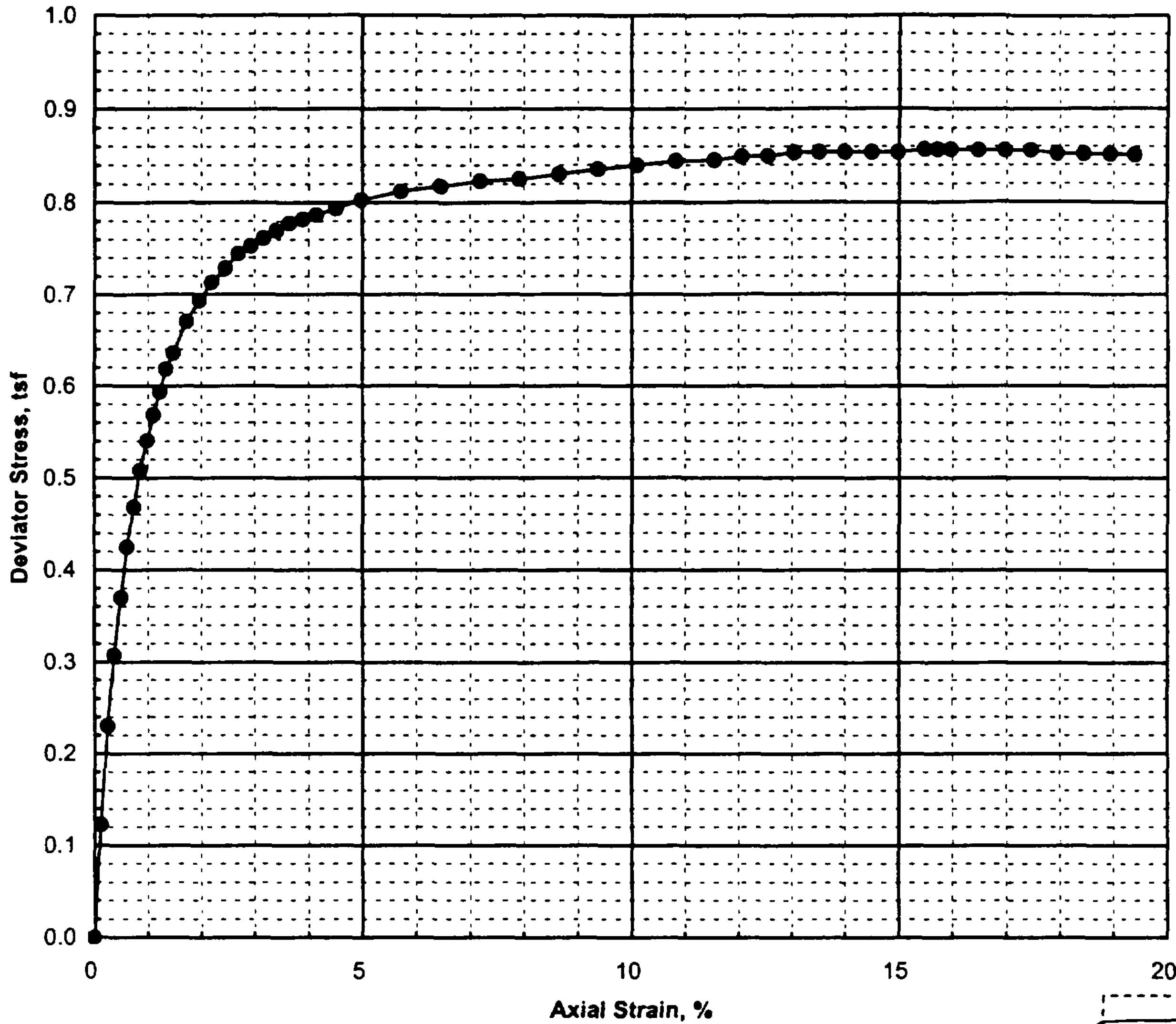
Water Content (%)	LL	PI	Length (in)	Diameter (in)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)
23.6	37	23	6.040	2.840	113.1	91.5

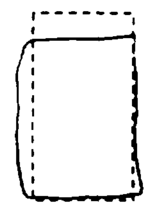
CL, brown f. sandy CLAY; roots noted, sample more sandy towards bottom.

Test Summary

Cell Pressure (tsf)	Axial Strain during confinement (%)	Compressive Strength (tsf)	Strain to Peak (%)	Strain Rate (%/min)
0.50	0.35	0.80	15.58	0.73

Project No. 23-99STL022.01	**Solutia, Cahokia**	**UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST** Boring No.: GB-4 Sample No.: S-1A Depth (ft): 0.5	
URS			November 2000





FAILURE SKETCH

Specimen Information

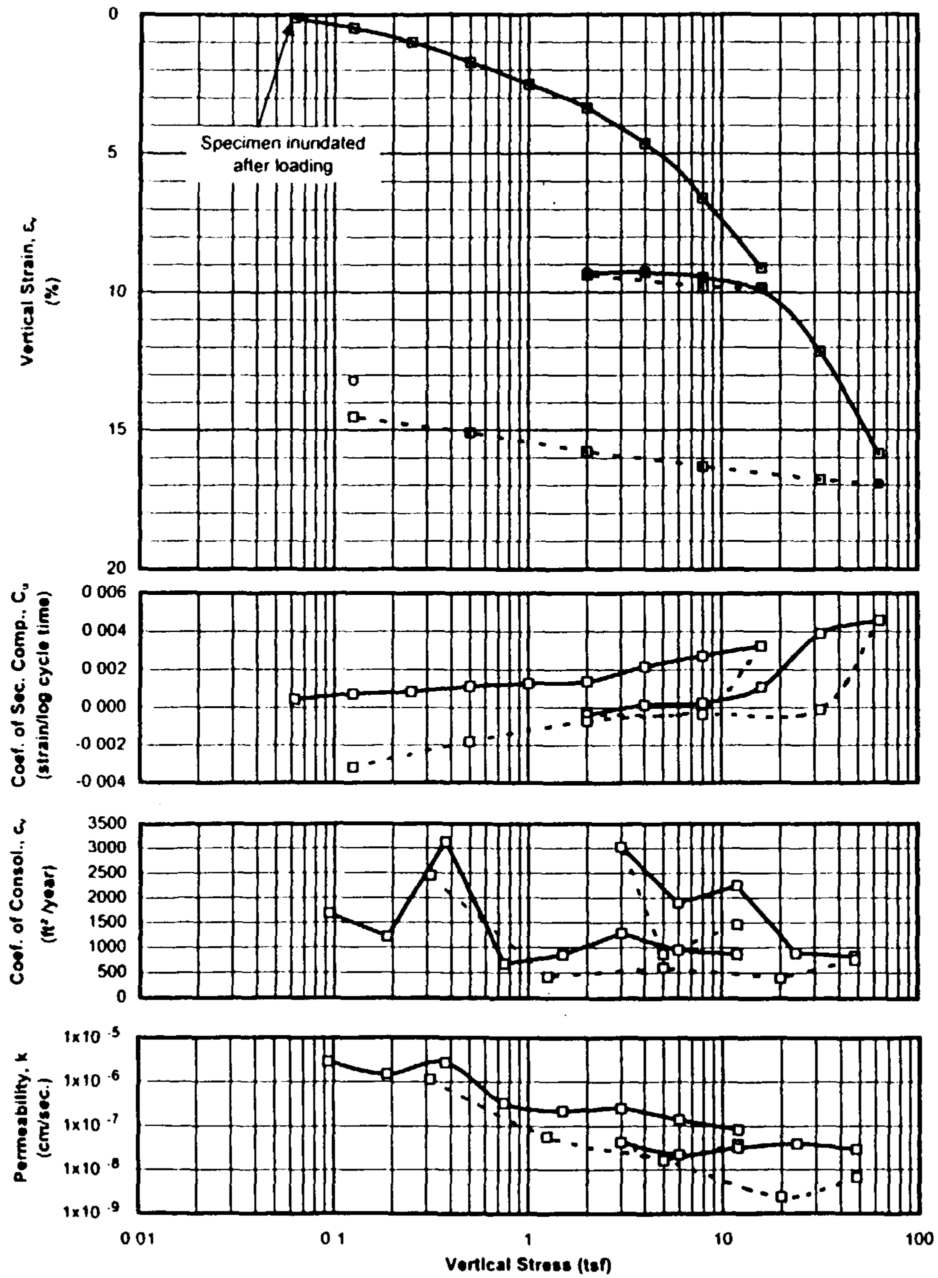
Water Content (%)	LL	PI	Length (in)	Diameter (in)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)
26.4			6.014	2.850	112.3	88.9

CL, dark brown silty CLAY, trace f. sand.

Test Summary

Cell Pressure (tsf)	Axial Strain during confinement (%)	Compressive Strength (tsf)	Strain to Peak (%)	Strain Rate (%/min)
1.00	0.60	0.86	15.48	0.73

Project No. 23-99STL022.01	Solutia, Cahokia	UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST Boring No.: GB-5 Sample No.: S-1A Depth (ft): 0.4	
URS			November 2000



SAMPLE INFORMATION

Boring:	GB-5
Sample:	S-1B
Depth:	0.95 feet
Elevation:	
Type:	3-inch thin wall tube
Description:	CL dark brown silty CLAY, some f. sand. LL = 36, PL = 24, PI = 12

SPECIMEN INFORMATION

(NOTE: Initial and final states refer to beginning and end of test)

Initial height:	0.61	inch
Diameter:	2.50	inch
Initial water content:	28.1	%
Initial total unit weight:	114.2	pcf
Initial dry unit weight:	89.1	pcf
Initial void ratio:	0.870	
Initial degree of saturation:	86	%
Final water content:	27.2	%
Final total unit weight:	121.3	pcf
Final dry unit weight:	95.3	pcf
Final void ratio:	0.748	
Final degree of saturation:	97	% (measured specific gravity = 2.67)

TEST SUMMARY

Construction Method:	Casagrande (Log)
Estimated preconsolidation stress (tsf):	10.2 (Range: 6.9 to 11.1)
Estimated in situ effective overburden stress (tsf):	
Compression Ratio (strain per log cycle stress):	0.124
Compression Index (void ratio per log cycle stress):	0.232
Swell Ratio (strain per log cycle stress):	0.007
Swell Index (void ratio per log cycle stress):	0.013
Recompression Ratio (strain per log cycle stress):	0.009
Recompression Index (void ratio per log cycle stress):	0.017
Remarks:	

LEGEND: □ End of primary o End of Stage ——— Loading - - - - - - Unloading

Test Date: 11/16/00 Tested By: RR/CMJ Checked By: [handwritten initials]

	Solutia, Cahokia	ONE DIMENSIONAL CONSOLIDATION TEST Boring: GB-5 Depth: 0 95 feet
URS Corporation	Project No. 23-99STL022.01	November 2000 Fig.

PROJECT:	Solutia, Cahokia				
PROJECT NO.:	23-99STL022.01	Initial height:	0.611 inch	Final height:	0.571 inch
BORING:	GB-5	Initial water content:	28.1 %	Final water content:	27.2 %
SAMPLE:	S-1B	Initial dry density:	89.1 pcf	Final dry density:	95.3 pcf
TEST:	C00150	Initial total density:	114.2 pcf	Final total density:	121.3 pcf
DEPTH, feet:	0.95	Initial saturation:	86 %	Final saturation:	97 %
BY:	RR/CMJ	Initial void ratio:	0.870	Final void ratio:	0.748
TEST DATE:	11/16/2000			Final strain:	6.5 %

EQUIPMENT:
Load Frame No.: 2
Ring Diameter: 2.5 inch

SPECIMEN DESCRIPTION: CL
dark brown silty CLAY, some f. sand.

G	LL	PL	PI
2.67	36	24	12

Load No.	Load (tsf)	d_{100} (inch)	t_{100} Strain (%)	t_{100} Void Ratio (-)	Final Strain (%)	Final Void Ratio (-)	c_v (ft²/year)	C_α (strain/logt)	Constrained Modulus (tsf)	Permeability (cm/sec)
1	0.063	0.0008	0.131	0.868	0.275	0.865	832.77	0.0004	47.75	5.26E-07
2	0.125	0.0030	0.484	0.861	0.785	0.856	1682.61	0.0007	17.69	2.87E-06
3	0.250	0.0061	0.994	0.852	1.222	0.847	1214.21	0.0008	24.50	1.49E-06
4	0.500	0.0105	1.716	0.838	2.157	0.830	3127.33	0.0011	34.66	2.72E-06
5	1.00	0.0154	2.524	0.823	2.975	0.815	673.82	0.0013	61.83	3.29E-07
6	2.00	0.0207	3.384	0.807	3.737	0.800	850.26	0.0014	116.35	2.20E-07
7	4.00	0.0284	4.656	0.783	5.213	0.773	1284.74	0.0022	157.27	2.46E-07
8	8.00	0.0402	6.586	0.747	7.280	0.734	949.99	0.0027	207.19	1.38E-07
9	16.0	0.0556	9.106	0.700	9.882	0.685	866.22	0.0032	317.54	8.23E-08
10	8.00	0.0599	9.798	0.687	9.758	0.688	1458.43	-0.0001	1155.19	3.81E-08
11	2.00	0.0574	9.398	0.694	9.303	0.696	870.52	-0.0004	1498.85	1.75E-08
12	4.00	0.0568	9.304	0.696	9.400	0.694	3029.10	0.0001	2133.85	4.28E-08
13	8.00	0.0578	9.459	0.693	9.571	0.691	1893.45	0.0003	2586.18	2.21E-08
14	16.0	0.0601	9.832	0.686	10.150	0.680	2240.16	0.0011	2141.75	3.16E-08
15	32.0	0.0742	12.140	0.643	13.093	0.625	889.28	0.0039	693.19	3.87E-08
16	64.0	0.0969	15.865	0.574	16.965	0.553	827.67	0.0046	859.17	2.91E-08
17	32.0	0.1026	16.794	0.556	16.769	0.557	754.47	-0.0001	3442.92	6.61E-09
18	8.00	0.0997	16.313	0.565	16.232	0.567	390.83	-0.0003	4990.62	2.36E-09
19	2.00	0.0964	15.773	0.575	15.569	0.579	595.65	-0.0007	1109.70	1.62E-08
20	0.500	0.0922	15.096	0.588	14.686	0.596	421.35	-0.0018	221.74	5.73E-08
21	0.125	0.0887	14.520	0.599	13.199	0.623	2446.85	-0.0032	65.06	1.13E-06

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	05-04-00
Time of Run:	2:09pm
Run By:	Martin Brungard
Input Data Filename:	C:SAUGET.IN
Output Filename:	C:SAUGET.OUT
Plotted Output Filename:	C:SAUGET.PLT

PROBLEM DESCRIPTION Solutia Sauget Landfill
-Exterior Slope Seismic Condition

BOUNDARY COORDINATES

3 Top Boundaries
5 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	40.00	30.00	40.00	3
2	30.00	40.00	110.00	60.00	1
3	110.00	60.00	150.00	60.00	1
4	30.00	40.00	150.00	40.00	3
5	0.00	30.00	150.00	30.00	2

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	1000.0	0.0	0.00	0.0	0
2	120.0	120.0	0.0	30.0	0.00	0.0	1
3	120.0	120.0	480.0	0.0	0.00	0.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	30.00
2	150.00	30.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	110.00	150.00	200.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

A Horizontal Earthquake Loading Coefficient Of0.100 Has Been Assigned

A Vertical Earthquake Loading Coefficient Of0.000 Has Been Assigned

Cavitation Pressure = 0.0 psf

```
A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

800 Trial Surfaces Have Been Generated.

 20 Surfaces Initiate From Each Of 40 Points Equally Spaced
Along The Ground Surface Between  X =  20.00 ft.
                             and  X =  30.00 ft.
```

Each Surface Terminates Between X = 120.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	29.23	40.00
2	33.73	37.82
3	38.35	35.90
4	43.07	34.25
5	47.88	32.88
6	52.75	31.78
7	57.69	30.96
8	62.66	30.42
9	67.65	30.17
10	72.65	30.20
11	77.64	30.53
12	82.60	31.13
13	87.52	32.02
14	92.39	33.19
15	97.17	34.63
16	101.87	36.35
17	106.46	38.33
18	110.93	40.57
19	115.26	43.07
20	119.45	45.80
21	123.47	48.77
22	127.31	51.97
23	130.97	55.38
24	134.42	59.00
25	135.27	60.00

Circle Center At X = 69.5 ; Y = 117.5 and Radius, 87.4

*** 1.354 ***

Failure Surface Specified By 28 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.10	40.00
2	28.73	38.11
3	33.43	36.41
4	38.21	34.91
5	43.04	33.63
6	47.92	32.54
7	52.84	31.67
8	57.80	31.00
9	62.78	30.55
10	67.77	30.31
11	72.77	30.29
12	77.77	30.47
13	82.75	30.87
14	87.71	31.48
15	92.65	32.30
16	97.54	33.33
17	102.38	34.57
18	107.17	36.01
19	111.89	37.66
20	116.54	39.50
21	121.10	41.55
22	125.58	43.78
23	129.95	46.20
24	134.22	48.81
25	138.37	51.59
26	142.40	54.55
27	146.30	57.68
28	148.95	60.00

Circle Center At X = 70.9 ; Y = 147.7 and Radius, 117.4

*** 1.356 ***

Failure Surface Specified By 28 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.85	40.00
2	28.48	38.12
3	33.19	36.43
4	37.96	34.95
5	42.79	33.66

6	47.67	32.58
7	52.60	31.70
8	57.55	31.03
9	62.53	30.57
10	67.52	30.32
11	72.52	30.28
12	77.52	30.44
13	82.51	30.81
14	87.47	31.40
15	92.41	32.19
16	97.31	33.18
17	102.16	34.38
18	106.96	35.79
19	111.70	37.39
20	116.37	39.19
21	120.95	41.18
22	125.45	43.36
23	129.85	45.73
24	134.15	48.28
25	138.34	51.01
26	142.41	53.91
27	146.36	56.98
28	149.93	60.00

Circle Center At X = 71.1 ; Y = 149.7 and Radius, 119.4

*** 1.357 ***

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.95	40.00
2	32.52	37.97
3	37.18	36.17
4	41.93	34.61
5	46.76	33.29
6	51.64	32.22
7	56.57	31.39
8	61.54	30.82
9	66.53	30.50
10	71.53	30.43
11	76.52	30.61
12	81.51	31.04
13	86.46	31.73
14	91.37	32.67
15	96.23	33.85
16	101.02	35.27
17	105.74	36.94
18	110.36	38.84
19	114.88	40.98
20	119.29	43.33
21	123.57	45.91

22	127.72	48.71
23	131.72	51.70
24	135.57	54.90
25	139.25	58.29
26	140.93	60.00

Circle Center At X = 70.4 ; Y = 129.4 and Radius, 98.9

*** 1.358 ***

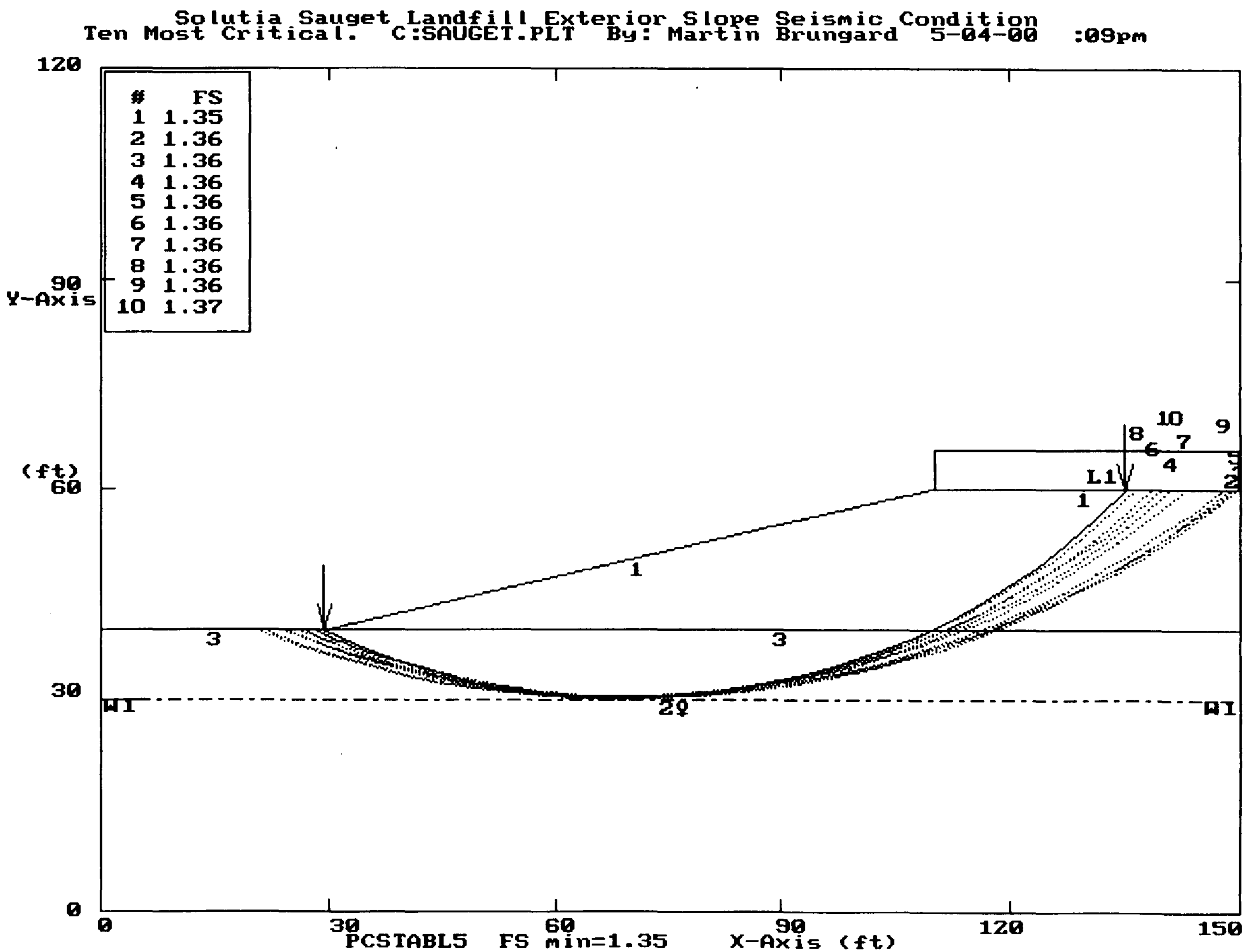
Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.51	40.00
2	25.15	38.12
3	29.85	36.43
4	34.62	34.93
5	39.45	33.63
6	44.33	32.53
7	49.25	31.62
8	54.20	30.92
9	59.17	30.42
10	64.16	30.12
11	69.16	30.02
12	74.16	30.13
13	79.15	30.44
14	84.12	30.95
15	89.07	31.67
16	93.99	32.58
17	98.86	33.70
18	103.69	35.01
19	108.45	36.52
20	113.16	38.21
21	117.79	40.10
22	122.33	42.18
23	126.80	44.44
24	131.16	46.88
25	135.42	49.49
26	139.57	52.28
27	143.61	55.23
28	147.52	58.34
29	149.44	60.00

Circle Center At X = 69.0 ; Y = 153.0 and Radius, 122.9

*** 1.359 ***

Failure Surface Specified By 26 Coordinate Points


Solutia Sauget Landfill Exterior Slope Seismic Condition
Ten Most Critical. C:SAUGET.PLT By: Martin Brungard 5-04-00 :09pm
FS
1 1.35
2 1.36
3 1.36
4 1.36
5 1.36
6 1.36
7 1.36
8 1.36
9 1.36
10 1.37
Y-Axis (ft)
0
30
60
90
120
X-Axis (ft)
0
30
60
90
120
150
L1
W1
PCSTABL5 FS min=1.35

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 05-04-00
Time of Run: 2:06pm
Run By: Martin Brungard
Input Data Filename: C:SAUGET5.IN
Output Filename: C:SAUGET5.OUT
Plotted Output Filename: C:SAUGET5.PLT

PROBLEM DESCRIPTION Solutia Sauget Landfill
-Exterior Slope Static Condition

BOUNDARY COORDINATES

3 Top Boundaries
5 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	40.00	30.00	40.00	3
2	30.00	40.00	110.00	60.00	1
3	110.00	60.00	150.00	60.00	1
4	30.00	40.00	150.00	40.00	3
5	0.00	30.00	150.00	30.00	2

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	1000.0	0.0	0.00	0.0	0
2	120.0	120.0	0.0	30.0	0.00	0.0	1
3	120.0	120.0	480.0	0.0	0.00	0.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	30.00
2	150.00	30.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	110.00	150.00	200.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

800 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 40 Points Equally Spaced Along The Ground Surface Between X = 20.00 ft.
and X = 30.00 ft.

Each Surface Terminates Between X = 120.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	29.23	40.00
2	33.73	37.82
3	38.35	35.90
4	43.07	34.25
5	47.88	32.88
6	52.75	31.78
7	57.69	30.96
8	62.66	30.42
9	67.65	30.17
10	72.65	30.20
11	77.64	30.53
12	82.60	31.13
13	87.52	32.02
14	92.39	33.19
15	97.17	34.63
16	101.87	36.35
17	106.46	38.33
18	110.93	40.57
19	115.26	43.07
20	119.45	45.80
21	123.47	48.77
22	127.31	51.97
23	130.97	55.38
24	134.42	59.00
25	135.27	60.00

Circle Center At X = 69.5 ; Y = 117.5 and Radius, 87.4

*** 1.943 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	26.67	40.00
2	31.20	37.88
3	35.83	36.01
4	40.56	34.38
5	45.37	33.02
6	50.25	31.91
7	55.18	31.07
8	60.14	30.50
9	65.13	30.19
10	70.13	30.16
11	75.13	30.39
12	80.10	30.89
13	85.04	31.65
14	89.94	32.68
15	94.77	33.97
16	99.52	35.52
17	104.18	37.33
18	108.74	39.38
19	113.19	41.67
20	117.50	44.20
21	121.67	46.96
22	125.69	49.94
23	129.54	53.13
24	133.21	56.52
25	136.60	60.00

Circle Center At X = 68.3 ; Y = 123.1 and Radius, 93.0

*** 1.956 ***

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	28.21	40.00
2	32.75	37.92
3	37.41	36.09
4	42.15	34.50
5	46.97	33.17
6	51.85	32.09
7	56.78	31.27
8	61.75	30.71
9	66.74	30.41
10	71.74	30.37
11	76.73	30.60
12	81.71	31.09
13	86.65	31.85
14	91.55	32.86
15	96.39	34.12
16	101.15	35.64
17	105.83	37.41
18	110.40	39.42

19	114.87	41.68
20	119.21	44.16
21	123.41	46.87
22	127.47	49.79
23	131.36	52.92
24	135.09	56.26
25	138.63	59.79
26	138.83	60.00

Circle Center At X = 69.9 ; Y = 125.3 and Radius, 95.0

*** 1.966 ***

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.95	40.00
2	32.52	37.97
3	37.18	36.17
4	41.93	34.61
5	46.76	33.29
6	51.64	32.22
7	56.57	31.39
8	61.54	30.82
9	66.53	30.50
10	71.53	30.43
11	76.52	30.61
12	81.51	31.04
13	86.46	31.73
14	91.37	32.67
15	96.23	33.85
16	101.02	35.27
17	105.74	36.94
18	110.36	38.84
19	114.88	40.98
20	119.29	43.33
21	123.57	45.91
22	127.72	48.71
23	131.72	51.70
24	135.57	54.90
25	139.25	58.29
26	140.93	60.00

Circle Center At X = 70.4 ; Y = 129.4 and Radius, 98.9

*** 1.976 ***

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.36	40.00
2	28.94	37.98
3	33.60	36.19
4	38.35	34.63
5	43.18	33.31
6	48.06	32.22
7	52.98	31.37
8	57.95	30.76
9	62.93	30.40
10	67.93	30.28
11	72.93	30.40
12	77.92	30.77
13	82.88	31.38
14	87.81	32.23
15	92.68	33.32
16	97.51	34.65
17	102.26	36.21
18	106.92	38.00
19	111.50	40.02
20	115.97	42.26
21	120.33	44.71
22	124.56	47.37
23	128.65	50.24
24	132.60	53.30
25	136.40	56.56
26	140.04	59.99
27	140.04	60.00

Circle Center At X = 67.9 ; Y = 132.7 and Radius, 102.4

*** 1.987 ***

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.90	40.00
2	30.49	38.01
3	35.16	36.25
4	39.92	34.71
5	44.75	33.40
6	49.63	32.32
7	54.56	31.47
8	59.52	30.86
9	64.50	30.48
10	69.50	30.35
11	74.50	30.45
12	79.49	30.79

13	84.46	31.37
14	89.39	32.18
15	94.28	33.23
16	99.11	34.51
17	103.88	36.01
18	108.57	37.75
19	113.17	39.70
20	117.68	41.87
21	122.07	44.26
22	126.35	46.85
23	130.50	49.64
24	134.51	52.62
25	138.37	55.80
26	142.08	59.15
27	142.94	60.00

Circle Center At X = 69.9 ; Y = 135.3 and Radius, 104.9

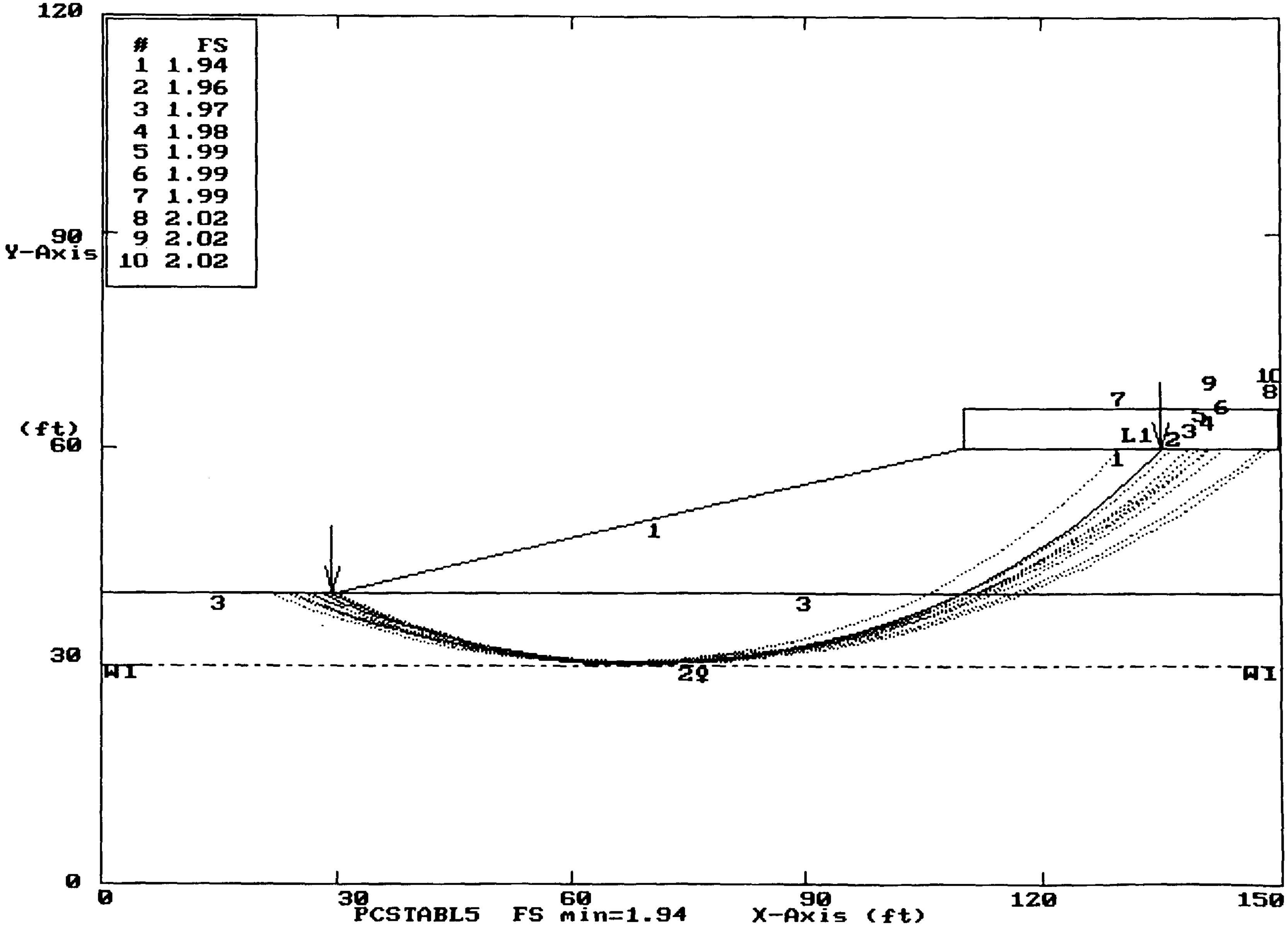
*** 1.988 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.00	40.00
2	34.49	37.79
3	39.10	35.87
4	43.83	34.24
5	48.65	32.90
6	53.54	31.87
7	58.49	31.14
8	63.47	30.73
9	68.47	30.62
10	73.46	30.83
11	78.44	31.34
12	83.37	32.17
13	88.24	33.30
14	93.03	34.73
15	97.72	36.46
16	102.29	38.48
17	106.73	40.78
18	111.02	43.35
19	115.14	46.18
20	119.08	49.26
21	122.82	52.59
22	126.34	56.14
23	129.63	59.90
24	129.71	60.00

Circle Center At X = 67.7 ; Y = 110.8 and Radius, 80.2

Solutia Sauget Landfill Exterior Slope Static Condition
Ten Most Critical. C:SAUGET5.PLT By: Martin Brungard 5-04-00 :06pm



--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 05-05-00
Time of Run: 3:28pm
Run By: Martin Brungard
Input Data Filename: C:SAUGET4.IN
Output Filename: C:SAUGET4.OUT
Plotted Output Filename: C:SAUGET4.PLT

PROBLEM DESCRIPTION Solutia Sauget
-2' cover thickness, 12% slope, seismic

BOUNDARY COORDINATES

1 Top Boundaries
3 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	35.00	180.00	56.60	1
2	10.00	34.20	180.00	54.60	2
3	10.00	34.00	180.00	54.40	1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	120.0	300.0	0.0	0.00	0.0	0
2	110.0	120.0	0.0	11.0	0.00	0.0	0

A Horizontal Earthquake Loading Coefficient
Of0.100 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned

Cavitation Pressure =   0.0 psf

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

25 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 1.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	4.00	33.40	12.00	34.34	0.20
2	170.00	53.30	178.00	54.30	0.20

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.22	35.15
2	1.50	34.95
3	2.48	34.74
4	3.21	34.06
5	4.05	33.50
6	176.68	54.18
7	177.25	55.00
8	177.93	55.73
9	178.17	56.38

*** 1.194 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.44	36.01
2	9.26	35.86
3	10.21	35.54
4	11.11	35.11
5	11.83	34.42
6	176.58	54.18
7	177.29	54.89
8	177.80	55.75
9	178.39	56.41

*** 1.203 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.52	35.66
2	5.90	35.32
3	6.79	34.88
4	7.77	34.65
5	8.65	34.18
6	9.63	34.00
7	172.21	53.53
8	172.69	54.40
9	173.40	55.11
10	173.97	55.88

*** 1.213 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.61	35.67
2	6.29	35.13
3	7.18	34.67
4	8.16	34.44
5	9.02	33.94

6	170.22	53.35
7	170.89	54.10
8	171.46	54.92
9	172.07	55.65

*** 1.218 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.84	35.58
2	4.92	35.55
3	5.90	35.36
4	6.61	34.65
5	7.57	34.38
6	8.44	33.89
7	173.61	53.66
8	174.30	54.38
9	174.98	55.11
10	175.54	55.94
11	175.59	56.07

*** 1.236 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.46	36.02
2	8.56	35.97
3	9.39	35.42
4	10.26	34.92
5	11.03	34.28
6	176.04	54.07
7	176.32	55.03
8	176.73	55.95
9	176.89	56.23

*** 1.242 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.29	35.87
2	7.38	35.80
3	8.38	35.78
4	9.14	35.13
5	10.09	34.82
6	10.86	34.18
7	172.95	53.62
8	173.27	54.57
9	173.71	55.47
10	173.88	55.87

*** 1.251 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.88	35.71
2	6.59	35.34
3	7.42	34.79
4	8.14	34.10
5	9.14	34.02
6	170.57	53.42
7	170.98	54.34
8	171.33	55.28
9	171.62	55.59

*** 1.276 ***

Failure Surface Specified By 9 Coordinate Points

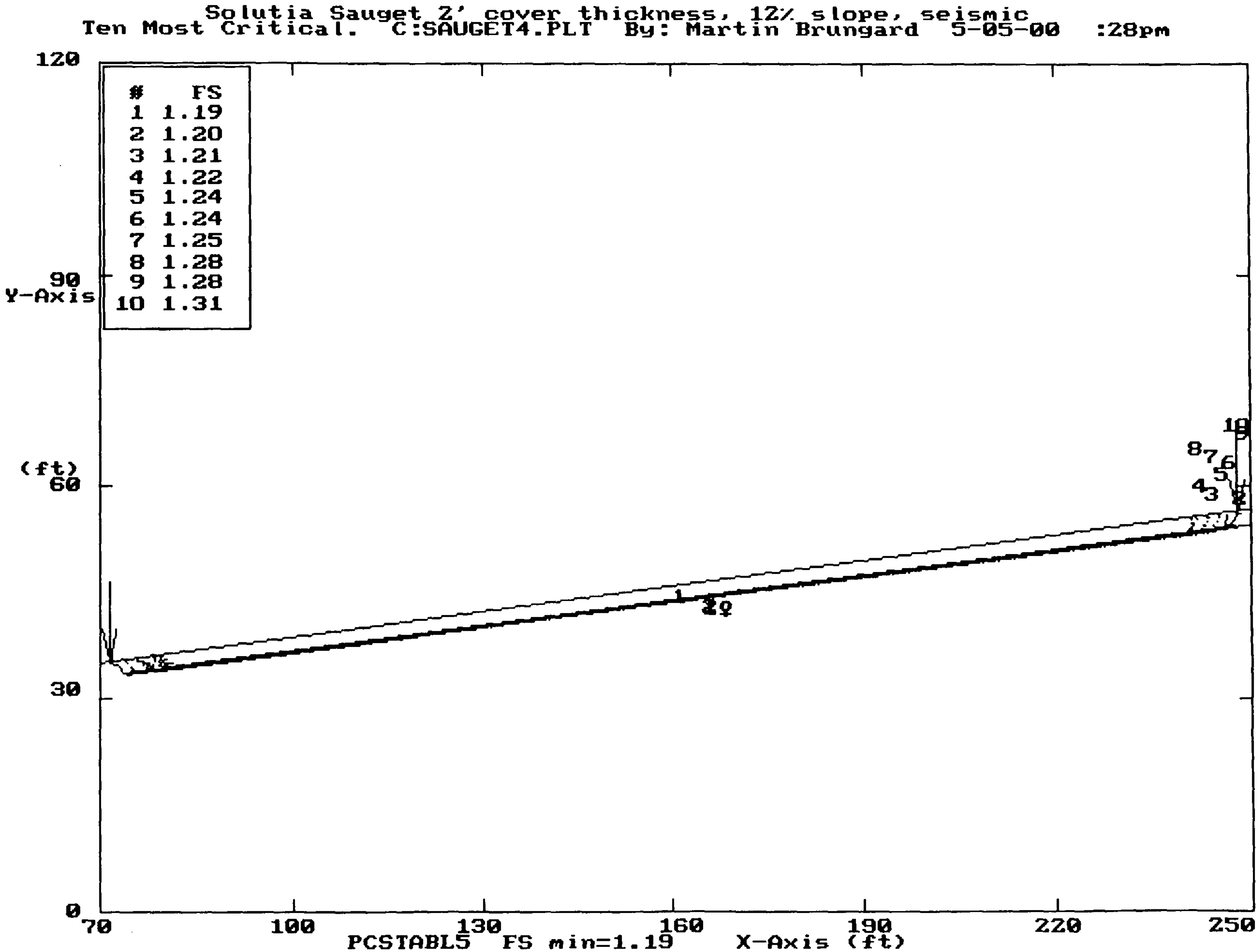
Point No.	X-Surf (ft)	Y-Surf (ft)
1	3.54	35.43
2	4.13	34.85
3	4.85	34.14
4	5.62	33.51
5	176.57	54.08
6	177.27	54.79
7	177.95	55.52
8	178.64	56.25
9	178.78	56.45

*** 1.278 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.66	35.92
2	8.35	35.24
3	9.23	34.76
4	10.22	34.62
5	11.16	34.28
6	176.03	54.00
7	176.34	54.95
8	176.56	55.93
9	176.75	56.21

*** 1.308 ***



Solutia Sauget 2' cover thickness, 12% slope, seismic
Ten Most Critical. C:SAUGET4.PLT By: Martin Brungard 5-05-00 :28pm
FS
1 1.19
2 1.20
3 1.21
4 1.22
5 1.24
6 1.24
7 1.25
8 1.28
9 1.28
10 1.31
Y-Axis (ft)
120
90
60
30
0
70
100
130
160
190
220
250
PCSTABL5 FS min=1.19 X-Axis (ft)

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	05-04-00
Time of Run:	2:47pm
Run By:	Martin Brungard
Input Data Filename:	C:SAUGET3.IN
Output Filename:	C:SAUGET3.OUT
Plotted Output Filename:	C:SAUGET3.PLT

PROBLEM DESCRIPTION   Solutia Sauget
-2' cover thickness, 12% slope, static

BOUNDARY COORDINATES

1 Top Boundaries
3 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	35.00	180.00	56.60	1
2	10.00	34.20	180.00	54.60	2
3	10.00	34.00	180.00	54.40	1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	120.0	300.0	0.0	0.00	0.0	0
2	110.0	120.0	0.0	11.0	0.00	0.0	0

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

25 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 1.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	4.00	33.40	12.00	34.34	0.20
2	170.00	53.30	178.00	54.30	0.20

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.22	35.15
2	1.50	34.95
3	2.48	34.74
4	3.21	34.06
5	4.05	33.50
6	176.68	54.18
7	177.25	55.00
8	177.93	55.73
9	178.17	56.38

*** 2.203 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.44	36.01

2	9.26	35.86
3	10.21	35.54
4	11.11	35.11
5	11.83	34.42
6	176.58	54.18
7	177.29	54.89
8	177.80	55.75
9	178.39	56.41

*** 2.220 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.52	35.66
2	5.90	35.32
3	6.79	34.88
4	7.77	34.65
5	8.65	34.18
6	9.63	34.00
7	172.21	53.53
8	172.69	54.40
9	173.40	55.11
10	173.97	55.88

*** 2.238 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.61	35.67
2	6.29	35.13
3	7.18	34.67
4	8.16	34.44
5	9.02	33.94
6	170.22	53.35
7	170.89	54.10
8	171.46	54.92
9	172.07	55.65

*** 2.246 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.84	35.58
2	4.92	35.55
3	5.90	35.36
4	6.61	34.65
5	7.57	34.38
6	8.44	33.89
7	173.61	53.66
8	174.30	54.38
9	174.98	55.11
10	175.54	55.94
11	175.59	56.07

*** 2.280 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.46	36.02
2	8.56	35.97
3	9.39	35.42
4	10.26	34.92
5	11.03	34.28
6	176.04	54.07
7	176.32	55.03
8	176.73	55.95
9	176.89	56.23

*** 2.291 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.29	35.87
2	7.38	35.80
3	8.38	35.78
4	9.14	35.13
5	10.09	34.82
6	10.86	34.18

7	172.95	53.62
8	173.27	54.57
9	173.71	55.47
10	173.88	55.87

*** 2.307 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.88	35.71
2	6.59	35.34
3	7.42	34.79
4	8.14	34.10
5	9.14	34.02
6	170.57	53.42
7	170.98	54.34
8	171.33	55.28
9	171.62	55.59

*** 2.352 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	3.54	35.43
2	4.13	34.85
3	4.85	34.14
4	5.62	33.51
5	176.57	54.08
6	177.27	54.79
7	177.95	55.52
8	178.64	56.25
9	178.78	56.45

*** 2.355 ***

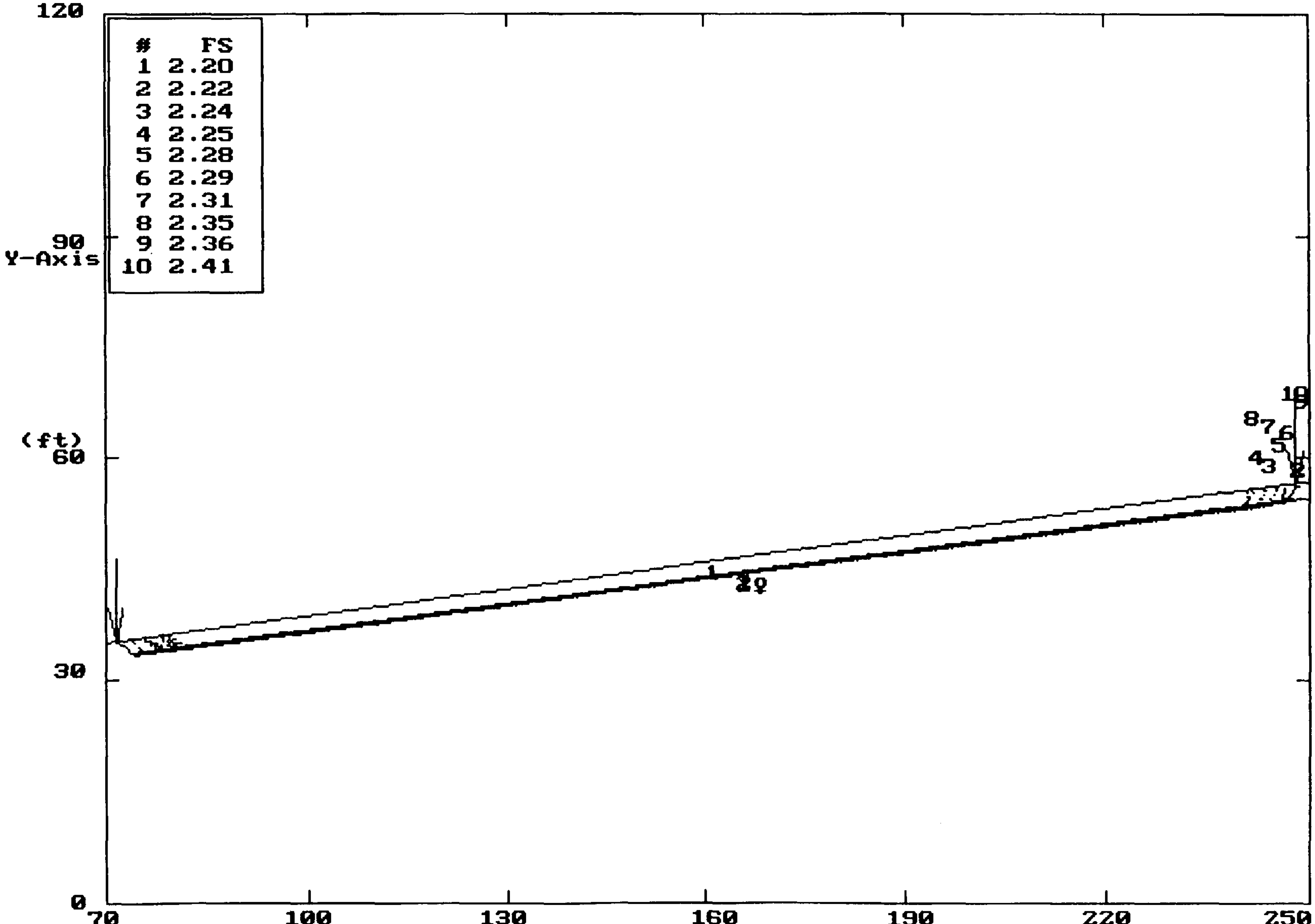
Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	7.66	35.92
2	8.35	35.24
3	9.23	34.76
4	10.22	34.62
5	11.16	34.28
6	176.03	54.00
7	176.34	54.95
8	176.56	55.93
9	176.75	56.21

*** 2.411 ***

Solutia Sauget 2' cover thickness, 12% slope, static
Ten Most Critical. C:SAUGET3.PLT By: Martin Brungard 5-04-00 :47pm



PCSTABL5 FS min=2.20

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	05-04-00
Time of Run:	2:14pm
Run By:	Martin Brungard
Input Data Filename:	C:SAUGET6.IN
Output Filename:	C:SAUGET6.OUT
Plotted Output Filename:	C:SAUGET6.PLT

PROBLEM DESCRIPTION   Solutia Sauget Landfill
-Interior Slope Seismic Condition

BOUNDARY COORDINATES

4 Top Boundaries
6 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	20.00	20.00	20.00	3
2	20.00	20.00	63.50	34.50	1
3	63.50	34.50	73.50	34.50	1
4	73.50	34.50	131.00	20.00	1
5	20.00	20.00	131.00	20.00	3
6	0.00	16.00	131.00	16.00	2

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	1000.0	0.0	0.00	0.0	0
2	120.0	120.0	0.0	30.0	0.00	0.0	1

3	120.0	120.0	480.0	0.0	0.00	0.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	16.00
2	131.00	16.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	63.50	73.50	200.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

A Horizontal Earthquake Loading Coefficient
Of0.100 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned

Cavitation Pressure = 0.0 psf

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

800 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 40 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft.

and X = 10.00 ft.

Each Surface Terminates Between X = 75.00 ft.
and X = 85.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.28	20.00
2	5.47	17.26
3	9.89	14.93
4	14.51	13.02
5	19.29	11.56
6	24.19	10.54
7	29.16	9.99
8	34.16	9.91
9	39.14	10.30
10	44.07	11.15
11	48.89	12.45
12	53.58	14.21
13	58.07	16.39
14	62.35	18.99
15	66.36	21.97
16	70.07	25.32
17	73.46	29.00
18	76.48	32.98
19	76.90	33.64

Circle Center At X = 32.5 ; Y = 63.2 and Radius, 53.4

*** 2.091 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.00	20.00
2	4.01	17.01
3	8.28	14.41
4	12.79	12.24
5	17.48	10.52
6	22.31	9.25
7	27.25	8.45
8	32.24	8.14
9	37.24	8.30
10	42.20	8.95
11	47.07	10.06
12	51.81	11.64
13	56.38	13.68
14	60.73	16.14
15	64.83	19.00
16	68.63	22.25
17	72.10	25.85
18	75.21	29.77
19	77.60	33.47

Circle Center At X = 33.0 ; Y = 60.0 and Radius, 51.9

*** 2.096 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.10	20.00
2	8.24	17.19
3	12.64	14.81
4	17.25	12.89
5	22.04	11.43
6	26.94	10.46
7	31.92	9.99
8	36.92	10.02
9	41.89	10.55
10	46.78	11.57
11	51.55	13.08
12	56.14	15.06
13	60.51	17.49
14	64.62	20.35
15	68.41	23.60
16	71.87	27.22
17	74.94	31.16
18	76.55	33.73

Circle Center At X = 34.1 ; Y = 59.8 and Radius, 49.8

*** 2.097 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.28	20.00
2	5.45	17.24
3	9.87	14.90
4	14.50	13.00
5	19.28	11.56
6	24.19	10.58
7	29.16	10.08
8	34.16	10.07
9	39.14	10.54
10	44.05	11.49
11	48.84	12.91
12	53.48	14.78
13	57.91	17.10
14	62.10	19.83
15	66.00	22.95
16	69.58	26.44
17	72.81	30.26
18	75.41	34.02

Circle Center At X = 31.8 ; Y = 61.7 and Radius, 51.6

*** 2.097 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.03	20.00
2	5.11	17.11
3	9.44	14.62
4	13.99	12.54
5	18.71	10.89
6	23.56	9.69
7	28.51	8.94
8	33.50	8.66
9	38.49	8.84
10	43.45	9.48
11	48.33	10.59
12	53.08	12.14

13	57.67	14.13
14	62.05	16.54
15	66.19	19.34
16	70.05	22.52
17	73.60	26.04
18	76.81	29.88
19	79.03	33.10

Circle Center At X = 34.0 ; Y = 62.4 and Radius, 53.7

*** 2.099 ***

Failure Surface Specified By 19 Coordinate Points

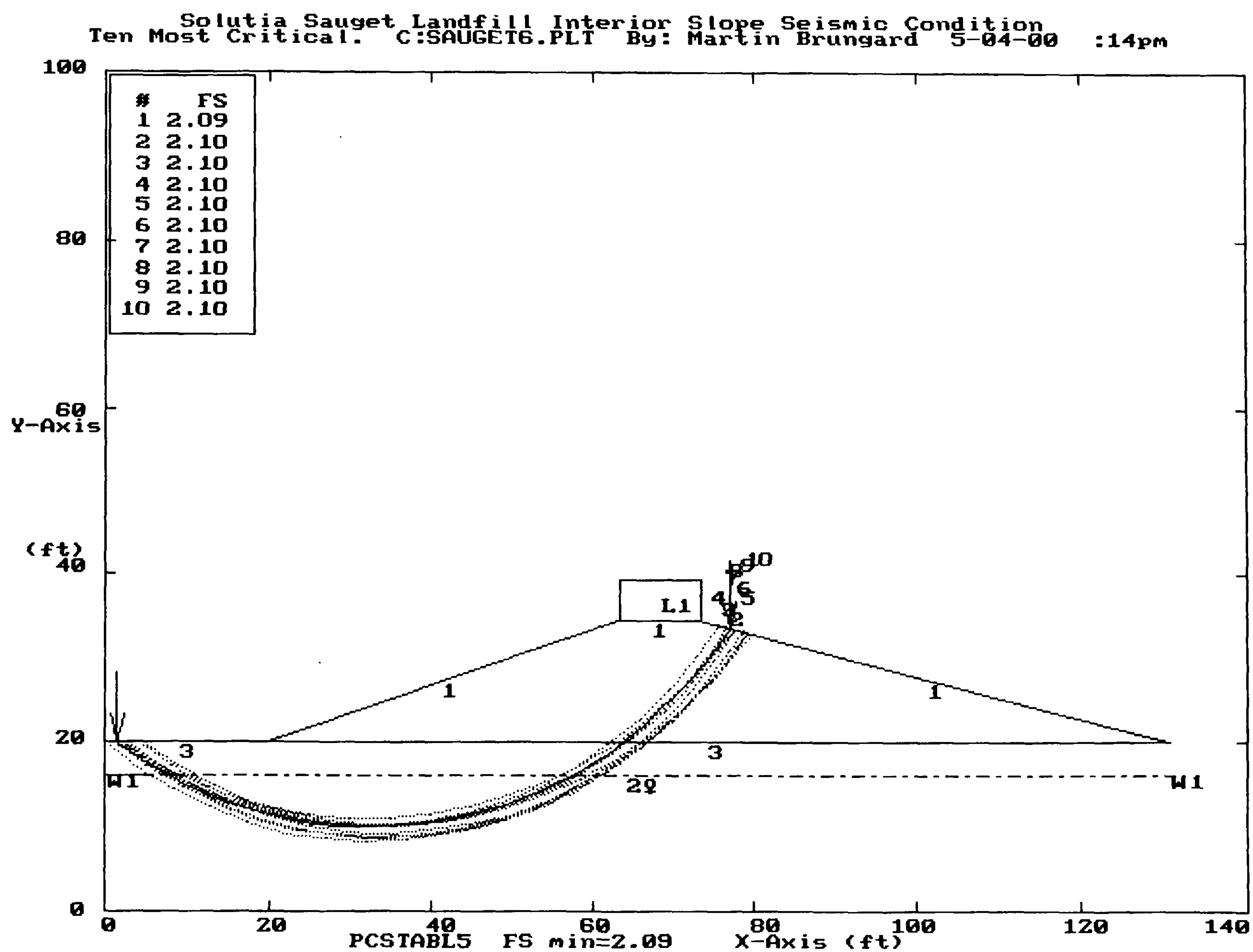
Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.05	20.00
2	6.11	17.08
3	10.43	14.56
4	14.97	12.46
5	19.69	10.82
6	24.54	9.63
7	29.49	8.91
8	34.49	8.68
9	39.48	8.92
10	44.43	9.64
11	49.28	10.84
12	54.00	12.50
13	58.54	14.60
14	62.85	17.12
15	66.91	20.05
16	70.66	23.36
17	74.07	27.01
18	77.12	30.97
19	78.54	33.23

Circle Center At X = 34.4 ; Y = 60.7 and Radius, 52.0

*** 2.099 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.62	20.00
2	8.78	17.23
3	13.20	14.89


Solutia Sauget Landfill Interior Slope Seismic Condition
Ten Most Critical. C:SAUGET6.PLT By: Martin Brungard 5-04-00 :14pm
FS
1 2.09
2 2.10
3 2.10
4 2.10
5 2.10
6 2.10
7 2.10
8 2.10
9 2.10
10 2.10
Y-Axis (ft)
0
20
40
60
80
100
120
140
X-Axis (ft)
PCSTABL5 FS min=2.09
L1
W1
1
3
2

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 05-04-00
Time of Run: 2:17pm
Run By: Martin Brungard
Input Data Filename: C:SAUGET7.IN
Output Filename: C:SAUGET7.OUT
Plotted Output Filename: C:SAUGET7.PLT

PROBLEM DESCRIPTION Solutia Sauget Landfill
-Interior Slope Static Condition

BOUNDARY COORDINATES

4 Top Boundaries
6 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	20.00	20.00	20.00	3
2	20.00	20.00	63.50	34.50	1
3	63.50	34.50	73.50	34.50	1
4	73.50	34.50	131.00	20.00	1
5	20.00	20.00	131.00	20.00	3
6	0.00	16.00	131.00	16.00	2

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	1000.0	0.0	0.00	0.0	0
2	120.0	120.0	0.0	30.0	0.00	0.0	1

3	120.0	120.0	480.0	0.0	0.00	0.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	16.00
2	131.00	16.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	63.50	73.50	200.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

800 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 40 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft. and X = 15.00 ft.

Each Surface Terminates Between X = 65.00 ft. and X = 80.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.39	20.00
2	14.55	17.24
3	19.02	14.99
4	23.71	13.27
5	28.58	12.11
6	33.54	11.52
7	38.54	11.52
8	43.51	12.10
9	48.37	13.26
10	53.07	14.98
11	57.53	17.23
12	61.70	19.99
13	65.52	23.22
14	68.94	26.87
15	71.91	30.89
16	73.91	34.40

Circle Center At X = 36.0 ; Y = 54.2 and Radius, 42.8

*** 2.837 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.08	20.00
2	12.13	17.07
3	16.49	14.63
4	21.11	12.70
5	25.91	11.30
6	30.84	10.46
7	35.83	10.19
8	40.82	10.48

9	45.74	11.35
10	50.54	12.76
11	55.14	14.72
12	59.49	17.18
13	63.53	20.12
14	67.22	23.51
15	70.49	27.29
16	73.31	31.42
17	74.76	34.18

Circle Center At X = 35.7 ; Y = 54.1 and Radius, 43.9

*** 2.838 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.00	20.00
2	9.10	17.14
3	13.49	14.74
4	18.11	12.83
5	22.91	11.43
6	27.83	10.56
7	32.82	10.23
8	37.82	10.44
9	42.76	11.19
10	47.60	12.48
11	52.26	14.27
12	56.70	16.57
13	60.87	19.33
14	64.72	22.52
15	68.20	26.11
16	71.27	30.06
17	73.89	34.32
18	73.92	34.39

Circle Center At X = 33.4 ; Y = 56.3 and Radius, 46.1

*** 2.839 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.00	20.00
2	9.10	17.13

3	13.47	14.72
4	18.09	12.79
5	22.88	11.37
6	27.80	10.47
7	32.79	10.11
8	37.78	10.28
9	42.73	10.99
10	47.58	12.23
11	52.26	13.98
12	56.73	16.22
13	60.93	18.93
14	64.82	22.08
15	68.34	25.62
16	71.47	29.53
17	74.15	33.75
18	74.41	34.27

Circle Center At X = 33.7 ; Y = 56.6 and Radius, 46.5

*** 2.839 ***

Failure Surface Specified By 17 Coordinate Points

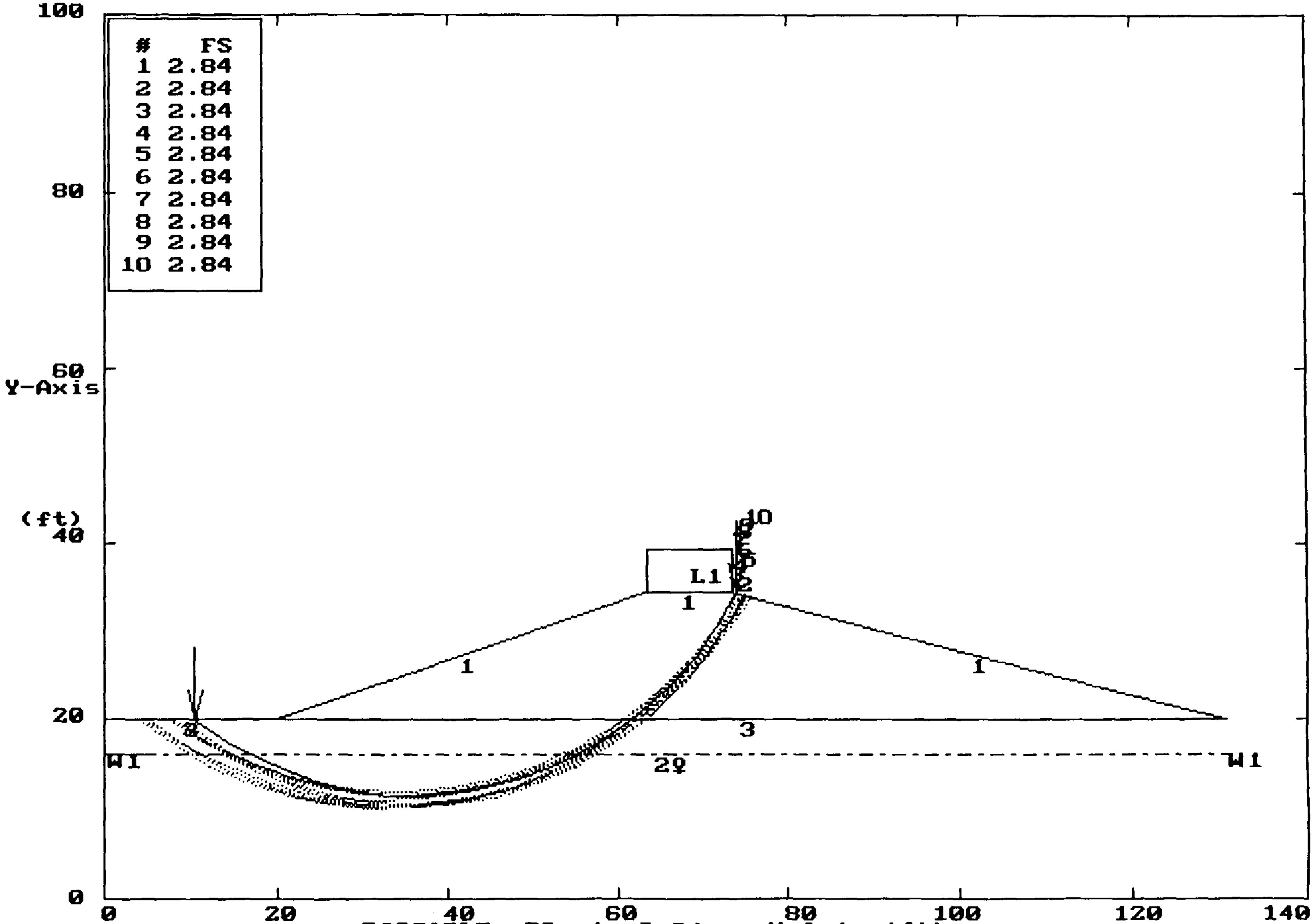
Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.31	20.00
2	11.57	17.38
3	16.08	15.22
4	20.79	13.54
5	25.64	12.36
6	30.60	11.69
7	35.60	11.54
8	40.58	11.92
9	45.50	12.81
10	50.30	14.21
11	54.93	16.10
12	59.34	18.46
13	63.48	21.27
14	67.30	24.49
15	70.76	28.10
16	73.83	32.05
17	75.11	34.09

Circle Center At X = 34.5 ; Y = 59.5 and Radius, 47.9

*** 2.840 ***

Failure Surface Specified By 17 Coordinate Points

Solutia Sauget Landfill Interior Slope Static Condition
Ten Most Critical. C:SAUGET7.PLT By: Martin Brungard 5-04-00 :17pm



PCSTABL5 FS min=2.84 X-Axis (ft)

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 05-05-00
Time of Run: 3:31pm
Run By: Martin Brungard
Input Data Filename: C:SOUGET2.IN
Output Filename: C:SOUGET2.OUT
Plotted Output Filename: C:SOUGET2.PLT

PROBLEM DESCRIPTION Solutia Sauget
-2' cover thickness, 3% slope seismic

BOUNDARY COORDINATES

1 Top Boundaries
3 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	35.00	180.00	40.40	1
2	10.00	33.30	180.00	38.40	2
3	10.00	33.10	180.00	38.20	1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	120.0	300.0	0.0	0.00	0.0	0
2	110.0	120.0	0.0	11.0	0.00	0.0	0

A Horizontal Earthquake Loading Coefficient
Of0.100 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned

Cavitation Pressure =   0.0 psf

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

25 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 1.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	4.00	33.20	12.00	33.40	0.20
2	170.00	38.00	178.00	38.20	0.20

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.42	35.16
2	5.51	35.08
3	6.29	34.46
4	7.18	34.01
5	8.16	33.77
6	9.02	33.27
7	170.22	38.03
8	170.79	38.85
9	171.43	39.62
10	171.97	40.16

*** 2.031 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.28	35.22
2	7.44	35.10
3	8.42	34.90
4	9.15	34.21
5	9.98	33.66
6	10.90	33.27
7	177.96	38.27
8	178.53	39.09
9	179.21	39.82
10	179.42	40.38

*** 2.047 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.27	35.16
2	5.90	34.60
3	6.79	34.16
4	7.77	33.93
5	8.65	33.46
6	9.63	33.27
7	172.21	38.01
8	172.69	38.88
9	173.40	39.59
10	173.86	40.22

*** 2.080 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.68	35.14
2	5.52	34.88
3	6.24	34.18

4	7.22	33.98
5	7.94	33.29
6	176.15	38.21
7	176.36	39.19
8	176.98	39.98
9	177.25	40.32

*** 2.187 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.62	35.20
2	7.23	34.66
3	8.03	34.06
4	9.02	33.94
5	9.79	33.30
6	171.48	38.11
7	172.10	38.89
8	172.61	39.75
9	172.64	40.18

*** 2.392 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.04	35.06
2	2.44	34.83
3	3.34	34.38
4	4.17	33.83
5	4.90	33.14
6	170.05	37.94
7	170.76	38.65
8	171.08	39.60
9	171.12	40.13

*** 2.672 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.64	35.08
2	2.89	34.83
3	3.63	34.16
4	4.61	33.95
5	5.61	33.88
6	6.37	33.23
7	176.27	38.10
8	176.88	38.89
9	177.36	39.76
10	177.73	40.33

*** 3.588 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.50	35.04
2	1.60	35.01
3	2.51	34.61
4	3.42	34.18
5	4.36	33.85
6	5.16	33.25
7	6.16	33.23
8	176.17	38.11
9	176.87	38.83
10	177.56	39.55
11	178.25	40.27
12	178.33	40.35

*** 3.706 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.73	35.05
2	1.82	34.96
3	2.69	34.47
4	3.66	34.26
5	4.40	33.58
6	5.34	33.23
7	175.03	38.16

8	175.06	39.16
9	175.74	39.89
10	176.05	40.28

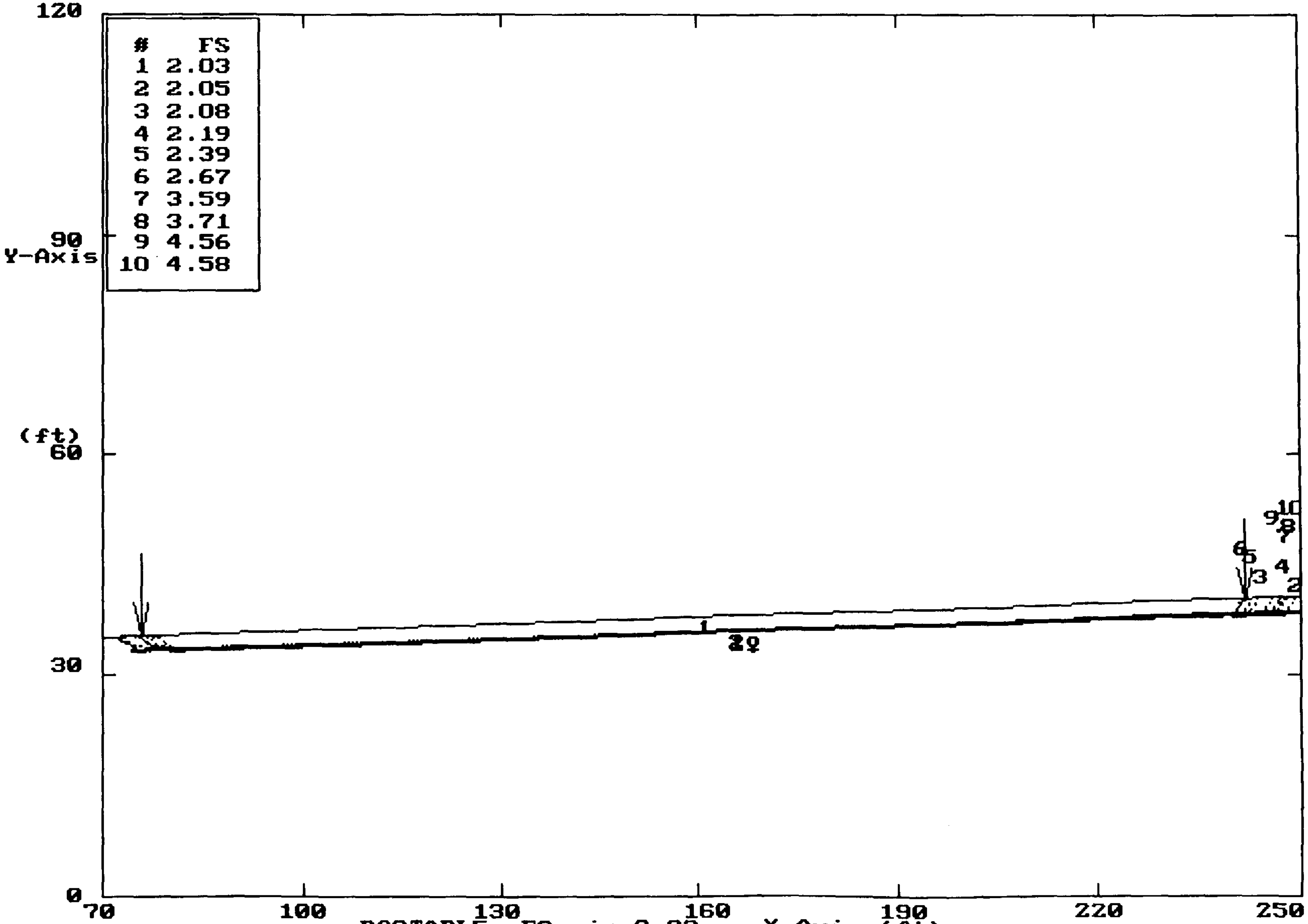
*** 4.556 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.31	35.07
2	2.94	34.82
3	3.72	34.19
4	4.63	33.77
5	5.47	33.24
6	175.98	38.10
7	176.19	39.08
8	176.89	39.79
9	177.33	40.32

*** 4.576 ***

Solutia Sauget 2' cover thickness, 3% slope seismic
Ten Most Critical. C:SOUGETZ.PLT By: Martin Brungard 5-05-00 :31pm



PCSTABL5 FS min=2.03

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	05-04-00
Time of Run:	2:45pm
Run By:	Martin Brungard
Input Data Filename:	C:SOUGET2A.IN
Output Filename:	C:SOUGET2A.OUT
Plotted Output Filename:	C:SOUGET2A.PLT

PROBLEM DESCRIPTION Solutia Sauget
-2' cover thickness, 3% slope static

BOUNDARY COORDINATES

1 Top Boundaries
3 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	35.00	180.00	40.40	1
2	10.00	33.30	180.00	38.40	2
3	10.00	33.10	180.00	38.20	1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	120.0	300.0	0.0	0.00	0.0	0
2	110.0	120.0	0.0	11.0	0.00	0.0	0

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

25 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 1.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	4.00	33.20	12.00	33.40	0.20
2	170.00	38.00	178.00	38.20	0.20

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.42	35.16
2	5.51	35.08
3	6.29	34.46
4	7.18	34.01
5	8.16	33.77
6	9.02	33.27
7	170.22	38.03
8	170.79	38.85
9	171.43	39.62
10	171.97	40.16

*** 8.817 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	7.28	35.22
2	7.44	35.10
3	8.42	34.90
4	9.15	34.21
5	9.98	33.66
6	10.90	33.27
7	177.96	38.27
8	178.53	39.09
9	179.21	39.82
10	179.42	40.38

*** 8.884 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.27	35.16
2	5.90	34.60
3	6.79	34.16
4	7.77	33.93
5	8.65	33.46
6	9.63	33.27
7	172.21	38.01
8	172.69	38.88
9	173.40	39.59
10	173.86	40.22

*** 9.027 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.68	35.14
2	5.52	34.88
3	6.24	34.18
4	7.22	33.98
5	7.94	33.29
6	176.15	38.21
7	176.36	39.19
8	176.98	39.98
9	177.25	40.32

*** 9.492 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.62	35.20
2	7.23	34.66
3	8.03	34.06
4	9.02	33.94
5	9.79	33.30
6	171.48	38.11
7	172.10	38.89
8	172.61	39.75
9	172.64	40.18

*** 10.376 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.04	35.06
2	2.44	34.83
3	3.34	34.38
4	4.17	33.83
5	4.90	33.14
6	170.05	37.94
7	170.76	38.65
8	171.08	39.60
9	171.12	40.13

*** 11.588 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.64	35.08
2	2.89	34.83
3	3.63	34.16
4	4.61	33.95
5	5.61	33.88
6	6.37	33.23

7	176.27	38.10
8	176.88	38.89
9	177.36	39.76
10	177.73	40.33

*** 15.553 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.50	35.04
2	1.60	35.01
3	2.51	34.61
4	3.42	34.18
5	4.36	33.85
6	5.16	33.25
7	6.16	33.23
8	176.17	38.11
9	176.87	38.83
10	177.56	39.55
11	178.25	40.27
12	178.33	40.35

*** 16.064 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.31	35.07
2	2.94	34.82
3	3.72	34.19
4	4.63	33.77
5	5.47	33.24
6	175.98	38.10
7	176.19	39.08
8	176.89	39.79
9	177.33	40.32

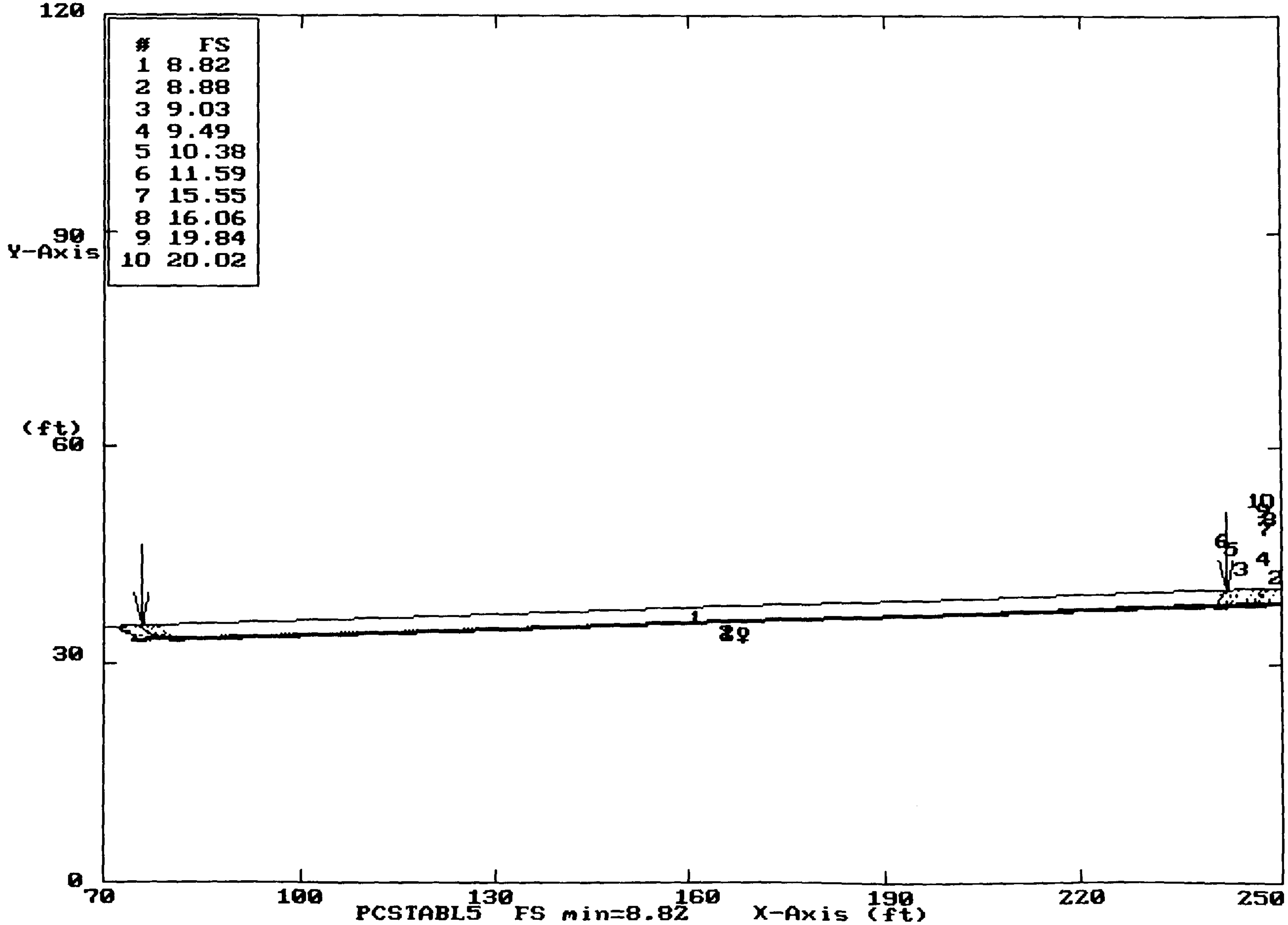
*** 19.836 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.73	35.05
2	1.82	34.96
3	2.69	34.47
4	3.66	34.26
5	4.40	33.58
6	5.34	33.23
7	175.03	38.16
8	175.06	39.16
9	175.74	39.89
10	176.05	40.28

*** 20.023 ***

Solutia Sauget 2' cover thickness, 3% slope static
Ten Most Critical. C:SOUGET2A.PLT By: Martin Brungard 5-04-00 :45pm



PCSTABL5 FS min=8.82

APPENDIX C

LINER SYSTEM COMPONENT DESIGN

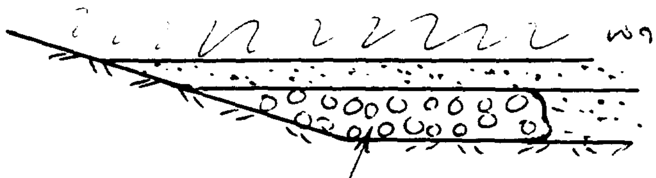
Gravel Drain Sizing

URS Greiner Woodward Clyde

Job: Solutia Sauget	Project No. C10000 3899.00	Page ___ of ___	Sheet 1 of 2
Description: Gravel Drain Sizing	Computed by: M. Brunggard	Date: 5/11/00	
	Checked by: Bill Weber	Date: 5/25/2000	
		Reference	

Purpose: Estimate cross-section for the gravel drainage blanket around the perimeter of the leachate collection layer.

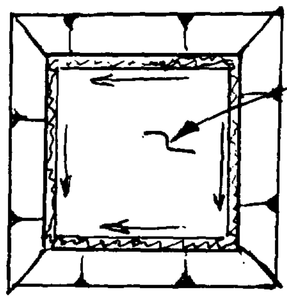
Configuration:



wastes
6" Sand Protective Layer
12" Sand Collection Layer

12" Thick × ? wide Gravel Layer.

Assumptions:



Bottom Dimensions ≈ 290' × 290'

Gravel Layer Length = 4 × 290'
= 1160'
or 580' per ~~side~~ leg

Sand Permeability = 1 × 10^{-2} cm/sec
3/8" Gravel Permeability = 10 cm/sec
estimated as follows:

Hazen Eqn. ⟶ $K = 100\, D_{10}^2$ (cm/sec), D_{10} (cm)
for 3/8" Gravel, the D_{10} is estimated as 4 mm or (0.4 cm)

$k = 100(0.4)^2 = 16$ cm/sec, use $\boxed{10 \text{ cm/sec}}$

Calculations:

When leachate level is over the top of gravel, the intake area into the gravel is (1' + w) where w is the gravel layer width.

Use a relatively high gradient into gravel (i = 0.5).

Flow into gravel
$$\left\{\begin{aligned} Q &= K\,i\,A \\ &= 1\times10^{-2}\text{ cm/sec }(0.5)(580' \times (1+w)) \\ &= 3.28\times10^{-4}\text{ ft/sec }(0.5)(580 \times (1+w)) \end{aligned}\right.$$

Use the bottom slope of 0.1 along the gravel path for gradient

Flow through gravel
$$\left\{\begin{aligned} Q &= KiA \\ &= 10\text{ cm/sec }(0.1)(1' \times (w)) \\ &= 0.328\text{ ft/sec }(0.1)(w) \\ &= 0.0328(w) \end{aligned}\right.$$

URS Greiner Woodward Clyde

Job Solution Sanget Project No. C1000 3899.00 Page ___ of ___ Sheet 2 of 2

Description Gravel Drain Sizing Computed by M. Brunnard Date 5/11/00

Checked by Bill Weber Date 5/25/2000

Reference

Set flow into gravel = Flow through gravel

$$0.0328(w) = 3.28\times10^{-4}(0.5)(580'\times(1+w))$$
$$0.0328(w) = 0.09512 + 0.09512(w)$$

$$\boxed{w = -1.5'}$$

gravel flow can't keep up w/ flow into gravel when W.L. is over gravel.

Use W.L. = 12" in collection layers

Flow into gravel $Q = 1\times10^{-2}\,\text{cm/sec}(0.5)(580'\times1')$
$= 0.09512\ \text{ft}^3/\text{sec}$

Flow through gravel $Q = 10\ \text{cm/sec}\ (0.1)(1'\times w)$
$= 0.0328\,w$

Set flows equal $0.0328\,w = 0.09512$
$\underline{w = 2.9'}$ $\underline{\text{say } 3'}$

$Q = 0.0328(3) = 0.098\ \text{ft}^3/\text{sec}$
$= 44$ gpm per leg

$= 88$ gpm for both legs

Conclusion: **88** gpm is probably greater than the pumping capacity for suction hoses able to fit into the HDPE piping 6" SDR 11 → I.D. = 6"

Therefore 3' wide gravel layer is OK for the cell's leachate collection layer.

Pipe Loading

Phillips Driscopipe
2929 N. Central Expwy, #300
Richardson,TX 75080
1-800-527-0662
www.driscopipe.com

Pipe Loading

Burial Calculation

Calculated by : M. Brungard
Company : URS
Address : 3676 Hartsfield Rd
State : Tallahassee
Phone :
Fax :
E-mail :

Calculated For : Solutia Sauget
Company :
Project :

Input Variables were as follows:

Using Driscopipe 1000

SDR = 11
Burial Depth to Crown of Pipe = 1 (ft)
Soil Density = 120 (pcf)
Water Table (feet above crown of pipe) = 0 (ft)
Other Loads = 3600 (psf)
Soil Modulous = 1000 (psi)
Conservative Long Term Pipe Modulous @ 23 Deg C = 35000

Allowable Ring Deflection @ 1.0% strain = 2.75
S(A) (Stress in Pipe Wall) = 129.17
P(T) (Pressure at Crown of Pipe = 25.83
P(CB) (Critical Buckling Pressure = 197.6
Calculated Ring Deflection (%) = 2.58
Crushing Design Safety Factor = 11.6 to 1
Wall Buckling Design Safety Factor = 7.6 to 1
Ring Deflection = acceptable

OK
MK
5/8/00

Comments : A wheel loading of 50 psi at ground surface was assumed (=7,200 psf). The stress influence diagram for a 1-ft wide tire shows that the stress at 1-ft depth (top of pipe) was about (0.3 × surface loading). A loading of (0.5 × surface loading) was used as a conservative estimate.
(0.5 × 7,200 psf = 3600 psf)

Checked Bill Weber
5/25/2000

Sump Sizing

URS Greiner Woodward Clyde

Page ____ of ____

Job: Solutia Sauget | Project No. C10000 3899.00 | Sheet 1 of 1

Description: Sump Sizing | Computed by: M. Brunggard | Date: 5/15/00

Checked by: Bill Webber | Date: 5/27/2000

Reference

Purpose: Estimate the minimum volume and size of gravel-filled sumps for the primary and secondary collection systems.

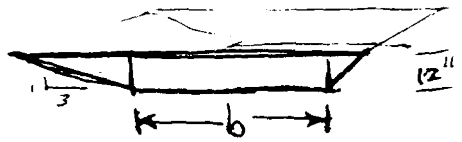
Method: Use the HELP model results for the containment cell performed during construction.

Use Avg Annual Flow rates and assume daily pump outs during construction.

From HELP model 5/8/00
- Primary: 58,350 ft³/yr = 1195 gpd
- Secondary: 8,512 ft³/yr = 175 gpd

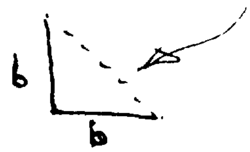
Analysis: Use gravel porosity of 0.35 for calculations. The maximum allowable head is 12 inches. Assume flat bottom in sump and include the gravel area on the side slopes.

— Primary: Gravel Sump Volume $= \dfrac{1195 \text{ gal}}{0.35} = 3{,}414 \text{ gal} = 456 \text{ ft}^3$



$V = b^2 + 2(1.5)b$
$= b^2 + 3b$

Since the plan of the sump will be as shown below double the volume to determine the correct side length



$(456 \text{ ft}^3)2 = b^2 + 3b$

$0 = b^2 + 3b - 912$

$\underline{b = 29'}$

— Secondary: Gravel Sump Volume $= \dfrac{175 \text{ gal}}{0.35} = 500 \text{ gal} = 66.8 \text{ ft}^3$

Double volume → $66.8(2) = 134 \text{ ft}^3$

$134 \text{ ft}^3 = b^2 + 3b$

$0 = b^2 + 3b - 134$

$\underline{b = 10.2'}$

Conclusion: ~~The cell configuration requires that the (b) dimension of the primary~~ (MB)

OK Use the sump sizes calculated.

Access Ramp Stability

URS Greiner Woodward Clyde

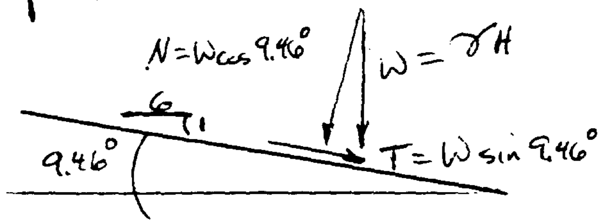
Job: Solutia Sauget
Description: Access Ramp Stability

Project No. C1000003879.00
Computed by: M. Brungardt
Checked by: Bill Weber

Page ___ of ___
Sheet 1 of 3
Date 5/19/00
Date 6/2/2000
Reference

Purpose: Design a system of slope reinforcement to allow equipment and soil to enter the containment cell without overstressing the lining system.

Configuration: The proposed containment cell will incorporate 6:1 ramps into the lined cell.



where: H = soil layer thickness, use 2'
γ = soil unit wt. = 120 pcf

Analysis: Assume the interface friction angle between the HDPE geomembrane and HDPE fly sheet is at least 6°. The value is more likely to be about 8°, but use the minimum value of 6°. Source: Designing w/ Geosynthetics, Koerner, Prentiss Hall, 1990.

Use a reinforcement to carry the down slope loading. The reinforcement loading is the difference between driving & resisting forces.

Driving Force: $T = W \sin 9.46^\circ$
$= 2'(120\text{ pcf}) \sin 9.46^\circ$
$= \underline{39.5\text{ psf}}$

Resisting Force: $F = W \cos 9.46^\circ (\tan 6^\circ)$
$= 2'(120\text{ pcf}) \cos 9.46 (\tan 6^\circ)$
$= \underline{24.9\text{ psf}}$

Ramp Slope Length = $6 \times 12'$ (height) = $\underline{72\text{ feet}}$

Reinforcement Tension Force = $(39.5\text{ psf} - 24.9\text{ psf}) \times 72'$
$= \underline{1051\text{ lbs/ft}}$

Note: This is just the soil veneer loading. Equipment will additionally load the reinforcement.

Equipment Loading: A small dump truck or dozer may weigh as little as 35,000 lbs. Larger equipment may weight upwards of 100,000 lbs. Use 50,000 & 100,000 lbs for analysis.

Equipment Weight (We) = 50,000 lbs or 100,000 lbs

Additional driving force = We sin 9.46°

or (50,000 lbs) sin 9.46° = $\boxed{8217 \text{ lbs}}$
(100,000 lbs) sin 9.46° = $\boxed{16,435 \text{ lbs}}$

If the equipment width is assumed as 10', then the driving force may be derived as:

8217 lbs / 10' = $\boxed{821.7 \text{ lbs/ft}}$
16,435 lbs / 10' = $\boxed{1,643.5 \text{ lbs/ft}}$

Total Reinforcement Loading = Soil Veneer Tension + Equipment Tension

= 1,051 lbs/ft + 822 lbs/ft = 1,873 lbs/ft

or

= 1,051 lbs/ft + 1644 lbs/ft = 2,695 lbs/ft

Use a factor of safety of 2 on reinforcement loads

Load range = 3,750 to 5,400 lbs/ft

The ultimate capacity of Tensar Uniaxial Geogrids is reported to be up to 2 times the dynamic strength reported by Tensor. ~~This~~ information was provided by Randy Fri~~tdeux~~ of Contech Construction Products.

Use a UX 1600 SB with a tensile strength of 3,585 lbs/ft. The factors od safety incorporated by Tensar are ~~to~~ accounts for long-term stress & creep limits. These are not required in the short-term use for these ramps.

Reinforcement Anchorage: Use a design anchorage strength of 5,400 lbs/ft to avoid having a sudden failure by over-stressing the geogrid to ~~its~~ ultimate strength.

Assume a soil backfill strength of 30° and a burial depth of 2'.

Job: Solutia Sauget
Description: Access Ramp Stability
Project No. C10003899.00
Computed by: M. Brungard
Date: 5/19/00
Checked by: Bill Weber
Date: 6/2/2000
Reference

For 3-dimensional reinforcements like UX 1600 SB, the efficiency is reported to be about 70% by: Designing w/ Geosynthetics, Koerner, Prentiss Hall, 1990.

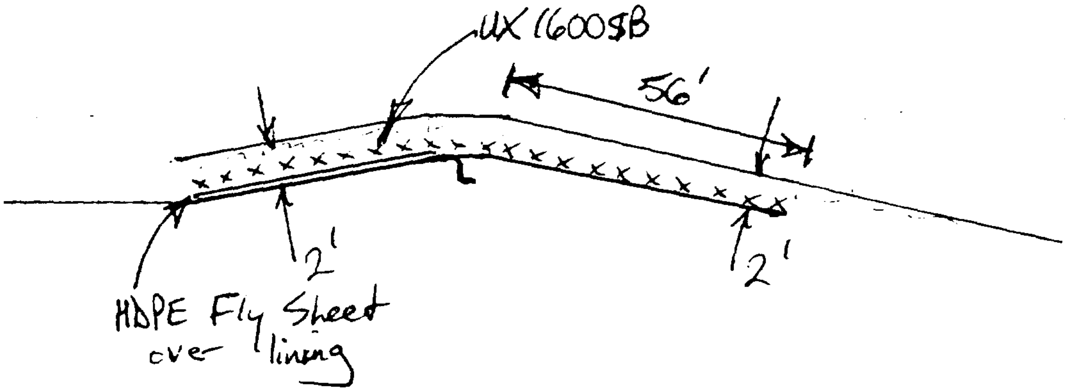
Anchorage Capacity = $E(\sigma \tan\phi) L_e$ where $E = 70\%$
$\sigma = 120\text{ pcf} \times 2'$
$\phi = 30°$
L_e = embedment length

$$5400 \text{ lbs/ft} = 0.70(240\text{ psf} \tan 30°)\ L_e$$

$$\underline{L_e = 56 \text{ feet}}$$

Conclusion: Use Tensar UX1600 SB for reinforcement. Use 2' soil cover over ramp slope to protect against mechanical damage to lining. Use a HDPE fly sheet between lining and geogrid to reduce friction transfer to lining.

Bury anchorage with about 2 feet of soil cover. use a granular fill to bed the geogrid anchorage. Anchorage length = 56 feet.



Geotextile Clogging Potential

URS

Job: Solutia Sauget	Project No. C1-7?59.00	Page ___ of ___
Description: Geotextile Clogging	Computed by: [illegible]	Sheet 1 of 1
	Checked by: J [illegible]	Date: 1? Jan 01
		Date: 1?-10-01
		Reference

Problem: Evaluate geotextile clogging potential for placed and compacted sediments

Given: Fabric - 16 oz nonwoven continuous filament use Synthetic Industries 1601 fabric

Sediment - use assumed conservative gradation based on site specific soils (attached)

$\therefore d_{85_{soil}} = 0.035 mm$

$d_{15_{soil}} = 0.0015 mm$

Fabric AOS = #140 = 0.1 mm

Analysis: Based on hydraulic load to leachate collection system use.

$$\frac{O_{95\,textile}}{d_{85\,soil}} < 3 \Rightarrow \frac{0.1}{0.035} = 2.8 \quad ok$$

$$\frac{O_{95}}{d_{15\,soil}} > 3 \Rightarrow \frac{0.1}{0.0015} = 66 \quad ok$$

Proposed 16 oz nonwoven fabric will meet the design stds.

GeoteX Nonwoven Geotextiles – METRIC VALUES

Earthstopping Solutions

PROPERTY	TEST METHOD	UNITS	VALUE	311	351	401	451	501	601	701	801	1001	1201	1601
MECHANICAL														
Grab Tensile Strength	ASTM D-4632	N	TYPICAL	400	485	575	600	730	820	930	1020	1220	1510	1820
			MARV	355	420	510	530	665	710	800	900	1110	1335	1690
Grab Elongation	ASTM D-4632	%	TYPICAL	60	60	60	60	60	60	60	60	60	60	60
			MARV	50	50	50	50	50	50	50	50	50	50	50
Puncture Strength	ASTM D-4833	N	TYPICAL	265	285	330	330	445	465	530	575	775	890	1220
			MARV	220	240	285	285	375	375	445	485	665	775	1065
Mullen Burst	ASTM D-3786	kPa	TYPICAL	1375	1430	1650	1860	2275	2205	2550	2685	3650	4410	5790
			MARV	1030	1270	1445	1585	1930	1930	2275	2410	3170	3995	5170
Trapezoidal Tear	ASTM D-4533	N	TYPICAL	175	220	265	265	355	310	400	420	530	600	755
			MARV	130	175	220	220	220	265	330	375	445	510	665
HYDRAULIC														
Apparent Opening Size (AOS)	ASTM D-4751	mm	TYPICAL	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.106	0.106	0.106
			MARV	0.212	0.212	0.212	0.212	0.212	0.212	0.212	0.180	0.150	0.150	0.150
Permittivity	ASTM D-4491	sec^{-1}	TYPICAL	2.70	2.60	2.40	2.20	2.10	1.80	1.80	1.80	1.50	1.30	1.00
			MARV	2.00	2.00	2.00	1.50	1.40	1.30	1.50	1.50	1.20	1.00	0.70
Permeability	ASTM D-4491	cm/sec	TYPICAL	0.29	0.39	0.30	0.29	0.28	0.32	0.38	0.48	0.40	0.40	0.39
			MARV	0.22	0.25	0.22	0.22	0.23	0.24	0.34	0.38	0.30	0.29	0.27
Water Flow Rate	ASTM D-4491	$l/min/m^2$	TYPICAL	6925	6110	6315	5500	5090	4885	5295	4885	4480	3665	2850
			MARV	4480	4480	5700	4885	4685	4480	4480	4480	3460	3055	2035
ENDURANCE														
UV Resistance	ASTM D-4355	% Retained @ 500 hrs	MARV	70	70	70	70	70	70	70	70	70	70	70
STANDARD PACKAGING														
Roll Width	Measured	meter	TYPICAL	3.81/4.57	3.81/4.57	3.81/4.57	3.81/4.57	3.81/4.57	3.81/4.57	3.81/4.57	4.57	4.57	4.57	4.57
Roll Length	Measured	meter	TYPICAL	109.8	109.8	109.8	109.8	109.8	91.5	91.5	91.5	91.5	91.5	91.5
Roll Area	Calculated	m^2	TYPICAL	418.05/ 501.66	418.05/ 501.66	418.05/ 501.66	418.05/ 501.66	418.05/ 501.66	348.38/ 418.05	348.38/ 418.05	418.05	418.05	418.05	418.05

NOTES

- ▲ Values reported i[n] weaker principle direction.
- ▲ "MARV" indicate[s] minimum averag[e] roll value calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample take[n] during quality assurance testin[g] will exceed the value reported.

SI® Geosolutions

Chattanooga, Tennessee USA

(423) 899-0444 ▲ (423) 899-7619 (Fax)

www.fixsoil[illegible]

GPD-NW-101

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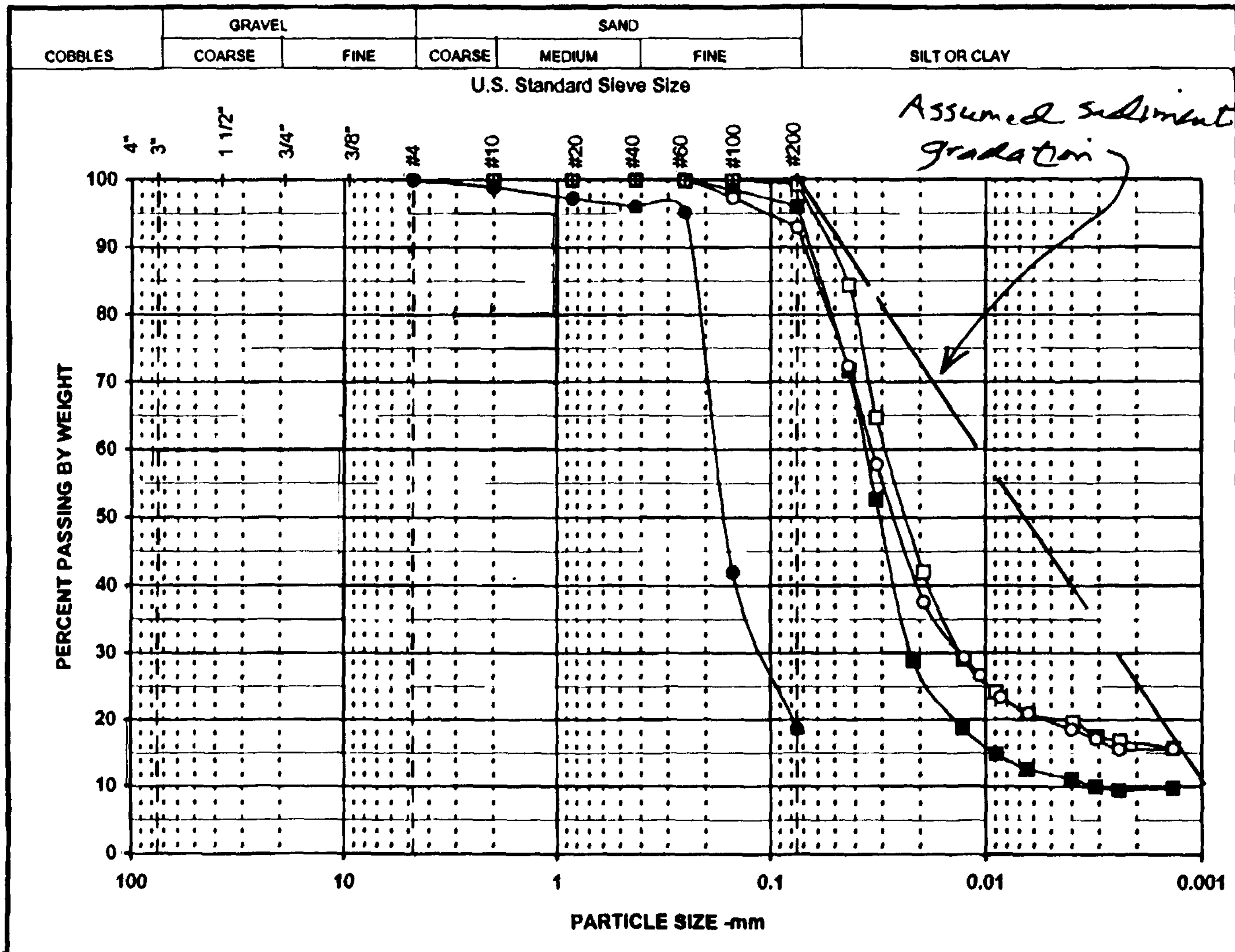
5/00-1[illegible]



Symbol	□	■	○	●
Boring	GB-4	GB -4	GB-4	GB-4
Sample	S-7	S-8	S-9	S-10
Spec				
Depth	12-14	14-16	16-18	18-20
% +3"				
% Gravel				
% SAND	0.6	3.9	7.1	81.4
% FINES	99.4	96.1	92.9	18.6
% -2μ	16	10	16	
Cc				
Cu				
LL	38			
PL	21	np		
PI	17			
USCS	CL	ML	CL-ML	SM
w (%)				27.1

Particle Size (Sieve #)	PERCENT FINER □	■	○	●
4"				
3"				
1 1/2"				
3/4"				
3/8"				
4				100.0
10		100.0		98.9
20	100.0	99.9	100.0	97.2
40	99.9	99.9	99.9	96.0
60	99.9	99.8	99.8	95.2
100	99.9	98.5	97.3	42.0
200	99.4	96.1	92.9	18.6

	DESCRIPTION AND REMARKS
□	gray silty CLAY.
■	gray SILT, trace f. sand. $d_{85} = 0.035$ mm
○	gray silty CLAY, trace f. sand. $d_{10} = 0.001$ mm
●	gray-brown f. SAND, some silt, trace c-m sand.

PARTICLE SIZE DISTRIBUTION
Solutia, Cahokia

Project No. 23-99STL022	November 2000	Figure

URS

Geonet Equivalent Performance

URS

Job [illegible]
Description Geonet Equivalent Performance

Project No. C1-3899.00
Computed by [illegible]
Checked by JHD

Page ___ of ___
Sheet 1 of 9
Date [illegible]
Date 1-16-01
Reference

Problem: Verify that a geonet layer is equivalent to 12 inches of sand with $k = 1\times10^{-2}$ cm/sec

Given: Use Tenax "cut sheet" for manufacturer data

Analysis: Transmissivity of sand $T = kt$

$$= 1\times10^{-2}\ \frac{cm}{sec} \times 30.48\ cm$$

$$= 0.305\ cm^2/sec$$

Tenax CE 450

T varies with σ_v

$\sigma_v \Rightarrow$

waste	15 ft × 115 pcf =	1725
liner system	2 ft × 110 pcf =	220
cover system	5 ft × 110 pcf =	550
σ_v =		2495 psf

(1 kPa = 20.8 psf) $\therefore \sigma_v = \frac{2495}{20.8} = 120$ kPa

From chart $T \cong 1.05\times10^{-3}\ \frac{m^2}{sec}$

Converting to $\frac{cm^2}{sec} \Rightarrow T = 1.05\times10^{-3}\ \frac{m^2}{sec} \times \left(\frac{100\ cm}{m}\right)^2$

$$T = 1.05\times10^{-3}\times10^{4} = 1.05\times10^{1}\ \frac{cm^2}{sec}$$

$T_{net} > T_{sand}$ / ok.

FJ 2/3

TENAX **CE**

Type: **450 - 600 - 750 - 900**

Geonets

TENAX **CE** geonets are high profile rhomboidal shaped mesh structures made by two sets of overlaid intersecting strands. The intersecting strands form overlaid sets of continuous deep channels which provide high flow capacity. These geonets are used in waste disposal and general civil engineering projects, where a high flow capacity is required.
TENAX **CE** geonets are manufactured from extrusion of High Density Polyethylene (HDPE), black in color; they are inert to chemical and biological conditions normally occurring in soil. Moreover they are treated with special additives to resist UV degradation.
TENAX **CE** geonets are available in a wide range of thicknesses and widths, so as to satisfy any design and installation need.

Typical applications

Load distribution, site leveling and mechanical protection of the geomembrane; drainage of the accidental leaks below primary; leachate and rain water collection above primary geomembrane; mechanical protection of the geomembranes when in contact with waste-materials and/or soil; drainage of liquids and gases present in the soil above and/or below the capping geomembrane.

PHYSICAL CHARACTERISTICS		**CE 450**	**CE 600**	**CE 750**	**CE 900**	**notes**
STRUCTURE		2 strands	2 strands	2 strands	2 strands	
POLYMER TYPE		HDPE	HDPE	HDPE	HDPE	
U.V. STABILIZER		carbon black	carbon black	carbon black	carbon black	
FOAMING AGENT		NO	NO	NO	NO	

DIMENSIONAL CHARACTERISTICS	**UNIT**	**CE 450**	**CE 600**	**CE 750**	**CE 900**	**notes**
THICKNESS at 20 kPa	mm	4.0	4.5	5.0	5.5	a.c
THICKNESS at 200 kPa	mm	3.8	4.2	4.8	5.2	a.c
UNIT WEIGHT	g/m²	450	600	750	900	a.d
ROLL WIDTH	m	2.3	2.3	2.3	2.3	a.g
ROLL LENGTH	m	100	50	50	50	a
ROLL DIAMETER	m	0.78	0.56	0.58	0.62	a
ROLL VOLUME	m³	1.41	0.73	0.79	0.89	a
ROLL GROSS WEIGHT	kg	103.5	69.0	86.3	103.5	a

TECHNICAL CHARACTERISTICS	**UNIT**	**CE 450**	**CE 600**	**CE 750**	**CE 900**	**notes**
HYDRAULIC FLOW RATE						
$i=1$ $\sigma v =$ 20 kPa	m²/ sec	1.18 E-03	1.39 E-03	1.41 E-03	1.44 E-03	a.b.e
$i=1$ $\sigma v =$ 100 kPa	m²/ sec	1.11 E-03	1.31 E-03	1.33 E-03	1.36 E-03	a.b.e
$i=1$ $\sigma v =$ 200 kPa	m²/ sec	1.00 E-03	1.24 E-03	1.26 E-03	1.28 E-03	a.b.e
$i=1$ $\sigma v =$ 500 kPa	m²/ sec	3.84 E-04	7.61 E-04	9.26 E-04	1.09 E-03	a.b.e
TENSILE STRENGTH	kN / m	4.0	5.0	7.0	9.0	a.b.f
ELONGATION AT PEAK	%	80	30	30	30	a.b.f

NOTES
a) Typical values
b) Longitudinal direction
c) ISO 9863
d) ISO 9864
e) ASTM D4716
f) ISO 10319
g) upon request available 3.9 m wide

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Man. Technology, Environment.

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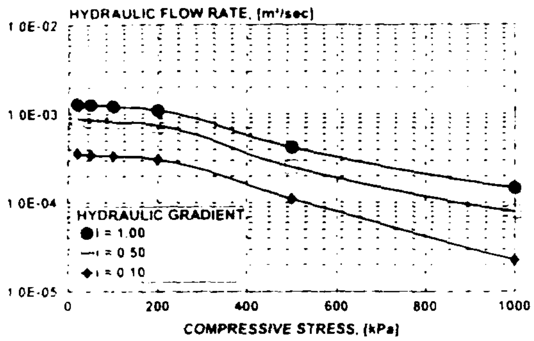
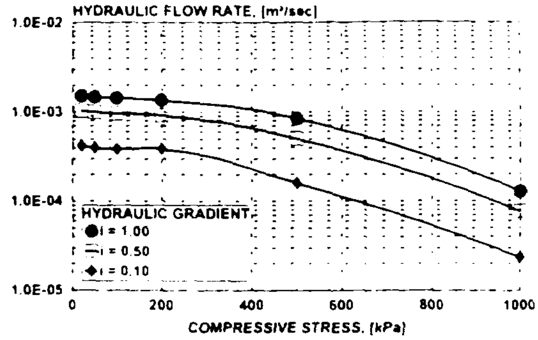
Typical Hydraulic Characteristics

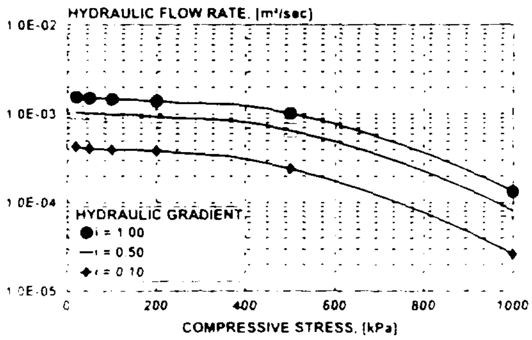
TENAX CE 450



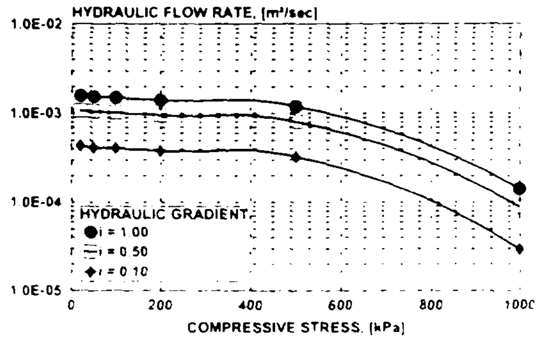
TENAX CE 600

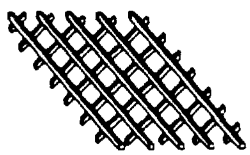


TENAX CE 750



TENAX CE 900





TENAX CE

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HDPE Elongation Calculations

URS

Job: Soletra Insight	Project No. 01-3899.00	Page ___ of ___	Sheet 1 of 2
Description: HDPE Elongation	Computed by: SMN	Date: 10 Jan 01	
	Checked by: JDH	Date: 10-1-01	
		Reference	

Problem: Evaluate strain in HDPE due to differential settlement of landfill base

Given: Total settlement values for various points on landfill base - see attached fig

Analysis

Maximum differential settlement
$4.1 - 2.0 = 2.1$ inches

Calculate strain values

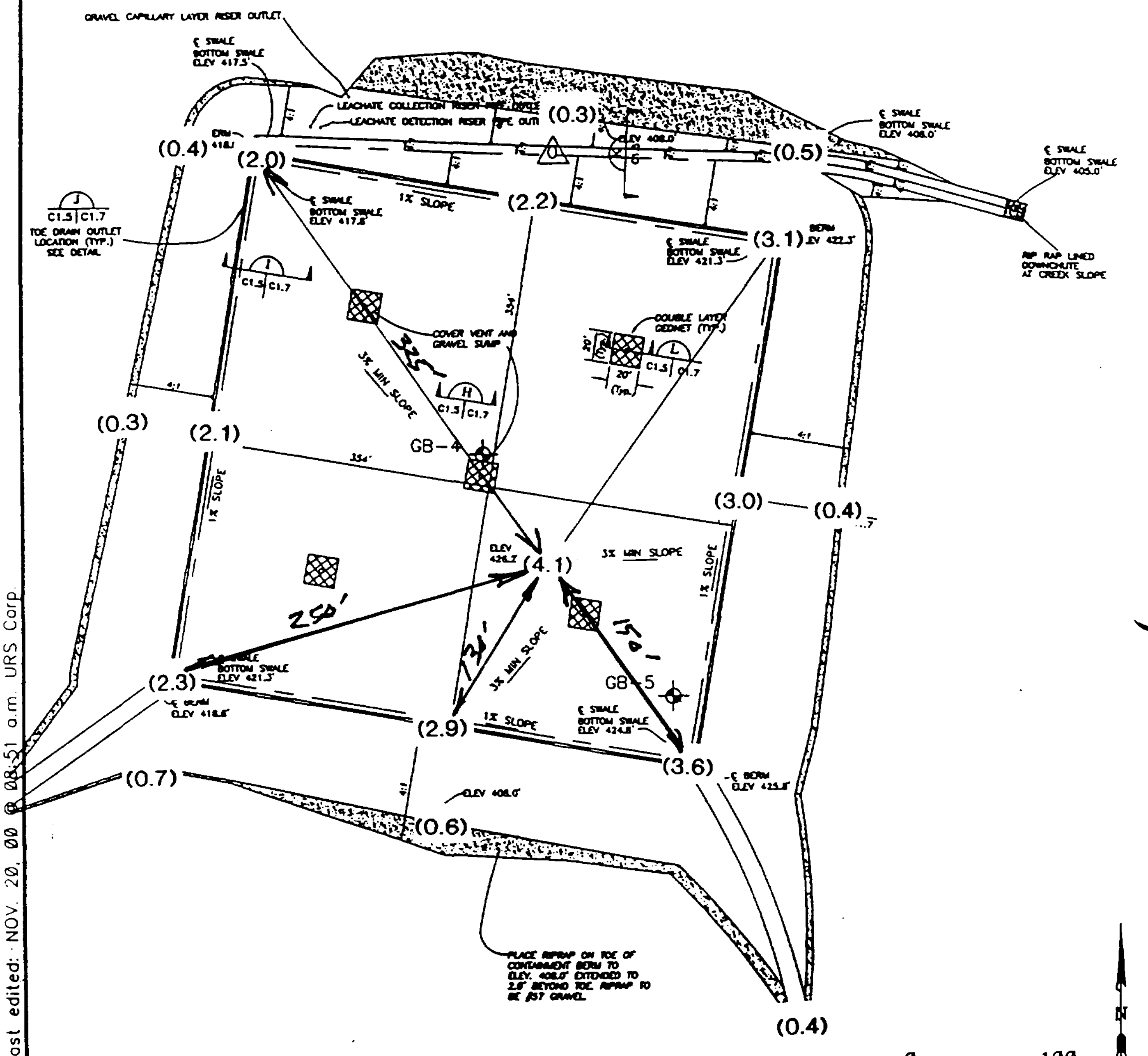
$\frac{1}{12}\frac{(4.1-2.0)}{325'}100 = 0.054\%$ $\frac{1}{12}\frac{(4.1-3.7)}{130'}100 = 0.077\%$

$\frac{1}{12}\frac{(4.1-2.3)}{550}(100) = 0.06\%$ $\frac{1}{12}\frac{(4.1-3.6)}{150'} = 0.028\%$

Observed strain due to differential settlement of the bottom varies from 0.028% to 0.077%

All values are << HDPE yield strain of 13%

Pg 27
2



LEGEND

BORING LOCATION

(6.0) - ESTIMATED TOTAL SETTLEMENT

TSCA CELL INVESTIGATION SAUGET AREA 1 CAHOKIA, ILLINOIS	PROJECT NO. 2399STL022.01

URS

DRN. BY: djd 11/20/00 DSGN. BY: tlc CHKD. BY:	Estimated Total Settlements Plan View	FIG. NO. 4

File: E:\99STL022\C1.5.DWG Last edited: NOV. 20, 00 @ 08:51 a.m. URS Corp.

GCL Loading Calculations

URS Greiner Woodward Clyde

Job: Solutia Sauget	Project No. C1000040051.00	Page ___ of ___	
Description: GCL Loading Calculations	Computed by: M. Brungard	Sheet 1 of 6	Date 11/2/00
	Checked by: R. Hayden		Date 11/3/00

Reference

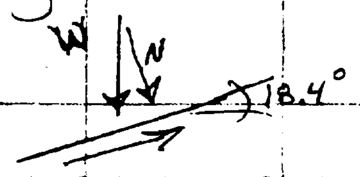
Purpose: Calculate the loading placed on the Geosynthetic Clay Lining (GCL) and evaluate the stability & stresses on the GCL.

Stresses During Filling:

Similar calculations were performed by M. Brungard on 10/24/00 titled "Lining System Tensile Stresses". Those calculations

A worst case evaluation of the allowable loads on the GCL was calculated by assuming a weight of soil was able to transmit the lateral loading via a 30° interface friction between the secondary HDPE lining and GCL. This assumes a textured HDPE lining.

The internal shear stress of 500 psf for the GCL was the limiting value in the equation.



$\tau = 500$ psf

$$\tau = W \cos 18.4^\circ \tan 30^\circ$$

$$500\,\text{psf} = W \cos 18.4^\circ \tan 30^\circ$$

$$W = \underline{912\ \text{psf}}$$

This is equivalent to about 7.5 feet of fill

$$\frac{912\ \text{psf}}{120\ \text{pcf}} = \underline{7.5'}$$

This fill height is specifically prohibited by the waste filling plan.

The interface friction between the GCL and underlying soil is unknown, but a worst case value has been selected from a set of 23 testing results published by Cetco in June '00. The general minimum value from these tests was about <u>15°</u>. This is for residual strength.

Job Solutia Sauget
Project No. C100004051.00
Description GCL Loading Calculations
Computed by M. Brungardt
Date 11/2/00
Checked by R. Hayden
Date 11/3/00
Reference

The maximum fill height when the GCL/soil interface controls is:

Driving Force = $W \sin 18.4°(L)$

Resisting Force = $W \cos 18.4 \tan 15 (L)$ + Tension in GCL

set Driving Force = Resisting Force i.e. F.S. = 1.0

$W \sin 18.4 (L) = W \cos 18.4 \tan 15 (L) + \text{Tension}$

$W(0.315)(L) = W(0.949)(0.268)(L) + \text{Tension}$

$W(0.060)(L) = \text{Tension}$

The minimum tensile strength for GCL materials are 90 lbs/ft (Bentomat ST)

$$W = \frac{\text{Tension}}{0.060(L)} = \frac{90 \text{ lbs/ft}}{0.060(L)} = \underline{1500/(L) \text{ lbs/ft}}$$

The filling plan limits the fill height to about 5' and (L) is therefore about 3 × 5' = 15'

$$W = \frac{1500 \text{ lb/ft}}{15'} = \underline{100 \text{ lbs/ft}^2}$$

This is equivalent to about $\frac{100 \text{ psf}}{120 \text{ pcf}}$ = 0.83'

not much

The maximum tensile strength for GCL materials are 150 lbs/ft (Bentomat DN)

$$W = \frac{150 \text{ lbs/ft}}{0.060(15)} = \underline{166 \text{ psf}}$$

This is equivalent to about $\frac{166 \text{ psf}}{120 \text{ pcf}}$ = 1.4'

still not much

URS Greiner Woodward Clyde

Job: Soluta Snuget	Project No. C100004051.00	Page ___ of ___	Sheet 3 of 6
Description: GCL Loading Calculations	Computed by: M. Brungard	Date: 11/2/00	
	Checked by: F. Hayden	Date: 11.3.00	

Reference

Stresses during Filling Summary:

The analysis shows that the GCL will not withstand much tension from the soil loading when the soil load is assumed to fully act on the secondary HDPE lining and GCL. Using the higher strength GCL product does not improve the situation much.

Fortunately, the combination of the passive soil wedge resistance and the limiting interface friction between the overlying geonets on either HDPE lining, prevents the driving force from being applied to the GCL/soil interface. The contribution of the passive soil wedge was demonstrated in the "Lining System Stability Analysis" by M. Brungard dated 10/19/00.

The passive wedge contribution is quantified in the following equation

$$P = c\left(h/\cos(45^\circ - 18.4^\circ)\right)$$ assumes $\phi = 0°$ (undrained)

where: c = waste undrained shear strength (psf)
h = thickness of waste veneer (ft)

For equipment ~~tra~~fficability on the waste mass, the waste's undrained shear strength must be at least 700 psf. (Taken from "Lining System Stability Analysis")

The referenced calculation also proved that the waste veneer thickness does not appreciably affect the slope stability. Assume (h) = 3 feet thick.

If $h = 3'$, then $w = h \times 120\ pcf = 360\ psf$ ← assumed moist unit weight for wastes

Driving Force $= (w)\sin 18.4(L) = 360\ psf\ (\sin 18.4)\ 15' = 1705\ lbs/ft$

Resisting Force $= (w)\cos 18.4(L)\tan 15° + \text{Tension} + c\left(\frac{h}{\cos(45-18.4)}\right)$

$= 360\ psf \cos 18.4 (15') \tan 15° + \text{Tension} + 700\left(\frac{3}{\cos 26.6}\right)$

$= 1373\ lb/ft + \text{Tension} + 2348\ lbs/ft$

$= 3721\ lbs/ft + \text{Tension}$

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Job Solutia Sauget	Project No. C100004051.00	Page ___ of ___
Description GCL Loading Calculations	Computed by M. Brungard	Sheet 4 of
	Checked by P. Haydon	Date 11/2/00
		Date 11/3/00
		Reference

Setting Driving Force = Resisting Force

$1705\ \text{lbs/ft} = 3721\ \text{lbs/ft} + \text{Tension}$

$-2016\ \text{lbs/ft} = \text{Tension}$

The negative result shows that no tension will be produced in the GCL.

* The GCL will not be loaded by the limited waste filling procedures.

GCL Anchorage:

Since the GCL will not be loaded in tension, the GCL anchorage is not critical. Any amount of embedment within the anchor trench be sufficient. The minimum GCL/soil interface friction value will be set high enough to equal the max. friction expected for the Geonet/HDPE interface..

Stresses After Filling:

The "Lining System Tensile Stresses" calculations by M. Brungard dated 10/20/00 proved that the waste mass cannot move down the cell slopes after the cell is filled. The compacted wastes will not laterally deflect or allow lateral movement. The slope stability for the waste mass over the slopes approaches infinity as the cell is filled. The driving force is much less than the resisting force.

Minimum GCL Interface Friction:

As shown above, the limited waste filling and filled cell both produce no stresses on the lining system. To limit the possibility of GCL movement during an inadvertant over stress during filling, the GCL interface friction values must be gr than the maximum interface friction for any of the overlying lining components. The maximum interface friction for Geonet to Smooth HDPE is about 16° per Eric Reed of GSE Lining Technologies.

Based on 16° ~~maximum~~ minimum interface friction, the minimum HDPE/GCL or GCL/soil must be greater than this value.

$$\text{Soil/GCL } \delta_{min} = \underline{\underline{16^\circ}}$$

The HDPE/GCL will require a textured interface.

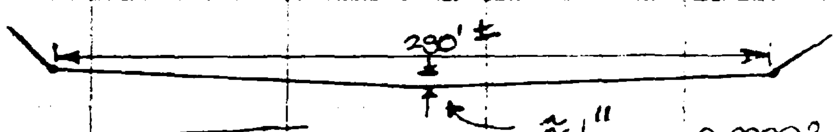
Information provided by Cetco dated 6/00 with ~~GI~~ testing results for Hydrated GCL w/ textured HDPE lining, shows that 10° to 15° (peak) was the minimum interface friction observed. Most values were 20° to 25° (peak). The tests show that the "normal" test stress levels were frequently over 50 psi. The maximum normal stress for this landfill is about 17 psi assuming 20' of soil or waste at 125 pcf.

Interface friction testing at lower normal stress ranges will provide higher friction values. The 10° to 15° (peak) results above are not applicable to this landfill configuration. The interface friction testing should not exceed a normal stress of about 20 psi in order to better model the landfill conditions expected.

It appears that a HDPE/GCL interface friction of at least $\underline{\underline{16^\circ}}$ should be achievable.

$$\text{HDPE/GCL } \delta_{min} = \underline{\underline{16^\circ}}$$

Settlement Loading: The settlement calculations for the landfill show that the magnitude is small and differential settlement is low. The strain in the lining system components was estimated as:



$$H = \sqrt{140^2 + \left(\tfrac{1}{12}\right)^2} = 140.00002 \qquad \varepsilon = \frac{0.00002}{140}$$

URS Greiner Woodward Clyde

Job: Solutia Sauget | Project No: 21000004051.00 | Page ___ of ___
Description: GCL Loading Calculations | Computed by: M. Brungard | Sheet 6 of
Checked by: | Date: 11/2/00
Date: 11/3/00

Reference

The strain in the GCL of 1.7×10^{-7} is insignificant since the GCL components are reported to have strains of 20 percent or more at rupture. The GCL will not be strained or stressed due to settlement.

Stresses After Filling Summary:

The calculations show that the GCL will not be stressed after filling provided that the minimum interface friction values of 16° are provided. The preconstruction material testing will have to prove this minimum value, for both the HDPE/GCL & GCL/Soil interfaces.

The settlement magnitude is very limited for this facility and the resulting strain in the GCL is insignificant compared to the strain capacity of any GCL component. No stresses due to settlement are anticipated.

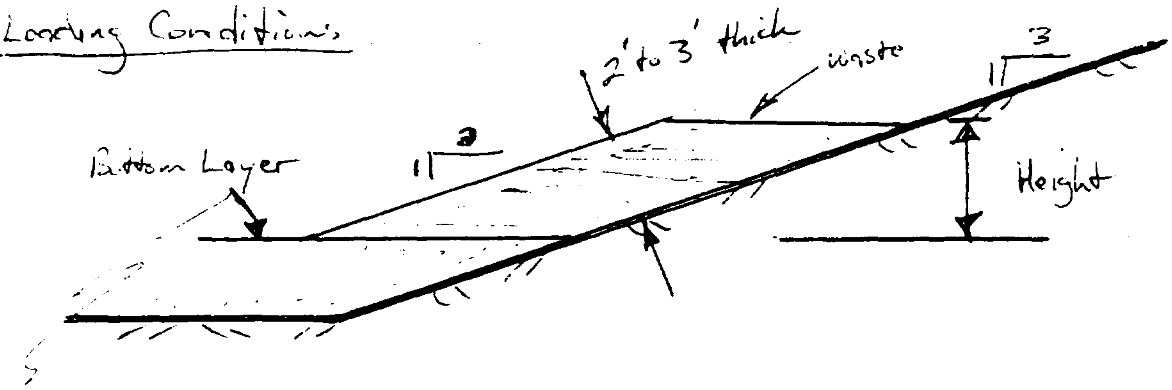
Liner System Stability Analysis

URS Greiner Woodward Clyde

Job: Solutia Sauget	Project No. C10001405(.00	Page ___ of ___	
Description: Lining System Stability Analysis	Computed by: M. Bumgard	Sheet 1 of 6	Date: 10/19/00
	Checked by: R. Hagan		Date: 10.25.00
		Reference	

Purpose: Evaluate the stability of all lining system components under the expected loading conditions.

Loading Conditions



Estimated Waste Strength

The actual strength of the wastes is currently unknown, but can be back-calculated from the requirements that the waste fill be "trafficable". The waste must be strong enough to support wheel loads.

The tire pressures commonly prescribed for light to medium-duty wheeled front end loaders was taken from a John Deere 544 maintenance sheet. The tire pressures range from 25 to 55 psi depending on tire size.

Using bearing capacity theory, the undrained shear strength can be estimated.

Applicable Eqn: $\sigma = c N_c$

where: c = undrained shear strength
$N_c = 5.14$ for undrained loading $\phi = 0°$
σ = Ultimate Bearing Capacity

Using the lowest tire pressure will result in the lower strength value. Set tire pressure to bearing capacity

$$25 \text{ psi} = c(5.14) \longrightarrow c = 4.86 \text{ psi}$$
$$= 700 \text{ psf}$$

URS Greiner Woodward Clyde

Job: Soluta Snuget	Project No. C1000 4051.00	Page ___ of ___	Sheet 2 of 6
Description: Lining System Stability Analysis	Computed by: M. Brungard	Date: 10/19/00	
	Checked by: K. Hanson	Date: ·25·00	Reference

Using the higher tire pressure shown the soil strength would need to be:

$$55 psi = c(5.14) \longrightarrow c = 10.7\ psi$$
$$= \underline{1540\ psf}$$

A small factor of safety is needed for the strengths above to account for the tractive forces to power the loader. Say 1.4 for the FS., so min. strength is <u>1,000 psf</u> and the strength may range up to <u>2200 psf</u>

Using the lower strength value will provide the most conservative slope stability results.

<u>Slope Stability</u>

Assume a block of soil is placed on the slope as shown on page 1. Vary the fill height & equipment loading to determine when failure occurs.

Actual Interface Friction values are not available for the analysis, since the construction contractor will be responsible for material acquisition. Conservative values taken from manufacturers literature will be used as the minimum acceptable interface friction values. These values will be used in this analysis.

Assumed Interface Friction Values

Geonet to Smooth HDPE = 12° } from phone conversation w/ Eric Rood
Geonet to Textured HDPE = 8° } of GSE Lining Technology.
GCL to Textured HDPE = 16° - from Bentomat Direct Shear Testing Summary dated 6/00

Use the 8° value for all geonet/HDPE interfaces.

Use 8° for δ since it is the lowest interface value

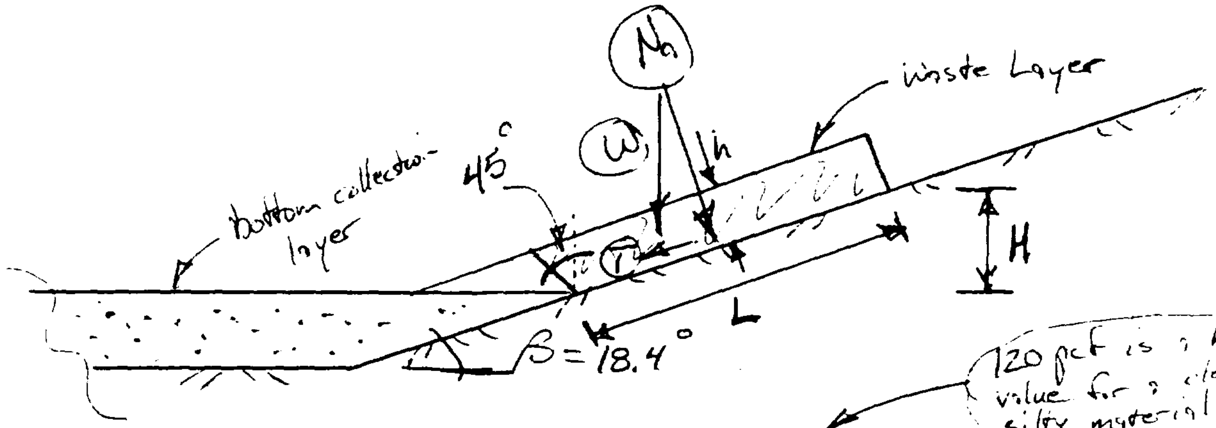
URS Greiner Woodward Clyde

Page ____ of ____

Job: Solutia Sauget
Description: Lining System Stability Analysis

Project No. C10000 4051.00
Computed by: M. Brungard
Checked by: R. Hayden

Sheet 3 of 6
Date 10/19/00
Date 10.26.00
Reference



120 pcf is a high value for a clayey or silty material

$N_a = W \cos\beta$ $\qquad W = hL\gamma$ + Equipment Load

$T = W \sin\beta$ (driving force)

Since the waste material is assumed to fail under undrained conditions, $\phi = 0°$

For $\phi = 0°$, the passive wedge failure angle is $45° + \phi/2 = 45°$ from vertical. The length of the passive failure surface is $h/\cos(45° - 18.4°)$.

The resisting forces are: $N_a \tan\delta$ interface friction

and $c(h/\cos(45-18.4))$ passive wedge

Disregard the friction contribution for passive wedge resistance

where: δ = interface friction angle
c = waste material cohesion.

$$FS = \frac{\text{resisting forces}}{\text{driving forces}} = \frac{N_a \tan\delta + c(h/\cos(45-18.4))}{W \sin\beta}$$

evaluate $h = 2'$, $L = 15'$, Eqpt. = 0 lbs

$N_a = hL\gamma\cos\beta = 2'(15')\,120\,\text{pcf}\,(\cos 18.4) = 3415$ lbs/ft
$T = hL\gamma\sin\beta = 2'(15')\,120\,\text{pcf}\,(\sin 18.4) = 1136$ lbs/ft
ok → $h/\cos(45-18.4) = 2'/\cos 26.6° = 2.22'$

$$F.S. = \frac{3415 \tan 5° + 1000\ \text{psf}\,(2.22')}{1136} = \frac{2700}{1136} = \underline{2.37}$$

OK

, if the equipment load is increased to 10,000 lbs/ft, the F.S. is

$$\frac{(10000+3600)\cos 18.4 \tan 8 + 1000\text{ psf}\,(2.22')}{(10000+3600)\sin 18.4} = \frac{4033\text{ lbs/ft}}{4292\text{ lbs/ft}} = \underline{\underline{0.94}}$$

$\boxed{\text{Fails}}$

, the max equipment loading is 8500 lbs/ft for F.S. = 1.0

Assuming the equipment width is 8' ⟶ the total equipment weight is 68,000 lbs

evaluate $h=3'$, $L=15'$, Eqpt = 0 lbs/ft

$$F.S. = \frac{5400 \cos 18.4 \tan 8 + 1000\text{ psf}\,(3.33')}{5400 \sin 18.4} = \frac{4050\text{ lbs/ft}}{1704\text{ lbs/ft}} =$$

$= \underline{\underline{2.37}}$ OK

This result indicates the F.S is insensitive to layer thickness

evaluate $h=2'$, $L=25'$, Eqpt = 0 lbs/ft

$$F.S. = \frac{6000 \cos 18.4 \tan 8 + 1000\text{ psf}\,(2.22')}{6000 \sin 18.4} = \frac{3020\text{ lbs/ft}}{1893\text{ lbs/ft}}$$

$= \underline{\underline{1.59}}$ OK

This result indicates that the F.S is sensitive to layer length up the slope. Considering the length equipment would have to be on the slope to place fill. Check

The max equipment loading is about 6,250 lbs/ft or ≈ 50,00

* This is marginal, especially if dynamic loadings are added. The layer length cannot be extended up the slope.

Evaluate the effect of having the waste strength lower than predicted. The waste pushed onto the side slopes may be slightly looser than the wastes placed on the bottom areas.

Assume $c = \underline{500 \text{ psf}}$

evaluate $h = 2'$, $L = 15'$, $E_{qpt} = 0$ lbs/ft

$$\frac{3600 \cos 18.4 \tan 8' + 500(2.22')}{3600 \sin 18.4} = \frac{1590 \text{ lb/ft}}{1136 \text{ lb/ft}} = \underline{\underline{1.40}}$$

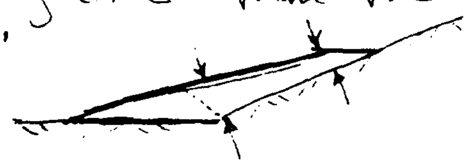
OK

the max. equipment load is about 2800 lbs/ft

or $\underline{22{,}400 \text{ lbs}}$

The result above shows that even poorly placed wastes will be stable when placed less than about 5 feet (vertically) or 15 feet (horizontally) up the slope. The actual limit of placement will probably be less than this. The specification for waste placement should prohibit equipment operation on the slope's waste veneer. This will ensure stable slope conditions.

Since the passive wedge resistance is directly proportional to the layer thickness, the F.S. will increase further if the base thickness is greater than the thickness at the top of the layer.



Summary

By using operational constraints during construction, the lining system stability will be maintained. Incrementally raising the wastes on the slopes will ensure that no lining system movement will occur.

Since the lowest interface friction values are on either side of the primary lining, the GCL/HDPE interface will not be stressed.

Access into the cell will be via 6:1 reinforced ramps that are designed to prevent the lining system being loaded in tension.

Sauget Lining System Stability Analysis

6 of 6

10/19/00

Maintenance—As Required

TIRE PRESSURES

544G, 544G TC

Tire Size	Type	Ply Rating	kPa	Operating Pressure* bar	psi
14 x 24	G2	10	300	3.8	55
15.5 x 25	L2	12	380	3.8	55
15.5R x 25	L2 or L3 Equiv	(1) Star	**Front 415	4.1	60
			**Rear 205	2.0	30
			Rear, alternate 310	3.1	45
17.5 x 25	L2	12	345	3.4	50
17.5 x 25	L3	12	345	3.4	50
17.5R x 25	L2 or L3 Equiv	(1) Star	**Front 345	3.4	50
			**Rear 170	1.7	25
			Rear, alternate 275	2.8	40
20.5 x 25	L2	12	275	2.8	40
20.5 x 25	L3	12	275	2.8	40
20.5 x 25	L3	16	345	3.4	50
20.5R x 25	L2 or L3 Equiv	(1) Star	**Front 205	2.0	30
			**Rear 170	1.7	25
			Rear, alternate 205	2.0	30
23.1 x 26	LS-2	10	140	1.4	20
28L x 26	LS-2	14	170	1.7	25

*Shipping pressure may vary from operating pressure.

**These radial tire pressures are recommended for optimum traction and tire wear under typical conditions. If a higher rear tire pressure is used, it should not exceed the alternate pressure listed.

TX,55,JC240 -10-29NOV94

To Martin

From Jim

244H

Maintenance—As Required

4. Turn on air supply. Stand to front or rear of tire when you add air to tire.

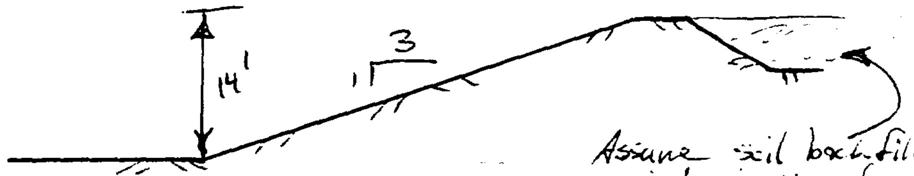
Tire Size	Type	Ply Rating	Cold Tire kPa	Inflation (bar)	Pressure (psi)
17.5/65 - 20	L2	10	200-230	(2-2.3)	29-34

Anchor System Design

Purpose: Design the anchorage details for the lining system components. Design the anchorage to pull out of the trench before reaching the HDPE yield stress.

Configuration: The lining system will use 60-mil HDPE membranes w/ geonets and GCL components.

The max slope height is 14 feet. The slope angle is 3 to 1. The max. slope length is 44 feet.



Assume soil backfill unit weight is 110 pcf. This is typical for moist clays & silts.

Allowable Tension in Lining:

The max allowable stress in the HDPE lining is 2800 psi to stay in the elastic range of the material.

For 60-mil lining, the max. force in the lining is:

$$2800\text{psi} \times 0.060'' = 168 \text{ lbs/in} = \underline{\underline{2016 \text{ lbs/ft}}} = (T)$$

Anchor Design:

Secondary

Use a 45° downslope, since 90° trenches are notoriously difficult to maintain in good condition prior to backfilling.

Assume $\delta = 16°$ on this side due to Textured HDPE/GCL interface.

Assume $\delta = 8°$ on this side due to HDPE/Geonet interface

$$T = 2016 \text{ lbs/ft} = \sqrt{2}\,(4')\,\frac{110\text{pcf}\,(4')}{2}\left(\cos 45° \tan 8° + \cos 45° \tan 16°\right)$$

$$+ \left(Le(110\text{pcf})\,4'(\tan 16° + \tan 8°)\right)$$

$$= 376 \text{ lbs/ft} + 188(Le)$$

URS Greiner Woodward Clyde

Job: Solutia Sauget	Project No. C10000405 1.00	Page ___ of ___	Sheet 2 of 2
Description: Lining System Anchorage Design	Computed by M. Brungard	Date 10/25/00	
	Checked by R. Haydon	Date 10/25/00	
		Reference	

$$2016 \text{ lbs/ft} = 376 \text{ lbs/ft} + 188 (Le)$$

$$1640 = 188 (Le)$$

$$\underline{8.7'} = (Le)$$ This is too long.

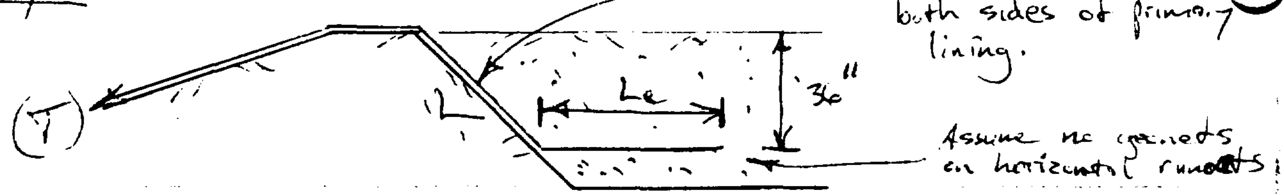
Assume that the Geonet & GCL do not extend onto the horizontal portion of the lining. The interface friction angle between smooth HDPE and a clay soil is assumed to have a typical value of $\underline{16°}$ (from Interface Friction Analyses, Schlegel Lining, 1987).

$$2016 \text{ lbs/ft} = 376 \text{ lbs/ft} + (Le)\, 110 \text{ pcf} (4')(\tan 16° \times 2)$$

$$1640 = 252 (Le)$$

$$\underline{6.5' = (Le)} \quad (\text{OK})$$

Primary



$$T = 2016 \text{ lbs/ft} = \sqrt{2}\,(3')\, \frac{110 \text{ pcf}\,(3')}{2} \cos 45° \tan 8° \times (2 \text{ sides}) +$$

$$Le\,(110 \text{ pcf})\, 3' \tan 17° \times (2 \text{ sides})$$

$$2016 = 139 \text{ lbs/ft} + 201 (Le) \text{ lbs/ft}$$

$$1877 = 201 (Le)$$

$$\underline{9.3' = Le} \quad (\text{OK})$$

Summary: The secondary lining will not be subjected to the proposed tensile forces. The textured HDPE/GCL will absorb & transmit the forces into the underlying grade. The primary lining ~~will~~ can undergo the proposed lining tension and it is therefore more important in this analysis. The (Le) lengths shown in these analyses are the maximum lengths. Shorter runout lengths are permissible.

Determined in Lining Tensile Stress calcs by M. Brungard 10/20/00

Lining Tensile Stress

URS Greiner Woodward Clyde

Job: Solutia Sauget	Project No. C1 0000 4051.00	Sheet 1 of 7	Page ___ of ___
Description: Lining System Tensile Stresses	Computed by M. Prungard	Date 10/20/00	
	Checked by R. [illegible]	Date [illegible]	

Reference

Purpose: Evaluate the stresses in all components of the lining system due to waste placement.

Assumptions: The lining system stability analysis performed by M. Prungard dated 10/19/00 proved ~~that~~ the lining system is stable when the soil placement on the slopes is limited and equipment is not allowed to operate on the slopes. As the cell is filled, the factor of safety for slope stability increases substantially. Downslope movement is significantly limited ~~after the~~ as the cell is filled.

Stresses During Filling

Evaluate the stresses imposed on the lining system components due to the limited soil layer placed on the side slopes during filling.

The lining system stability analysis determined that the interface friction between the primary geonet & primary lining is about:

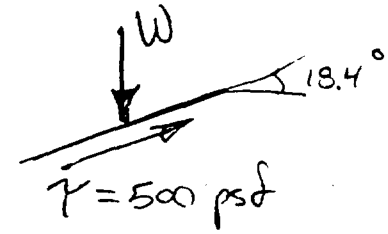
$$\underbrace{(8500 \text{ lbs/ft}}_{\text{eqpt.}} + \underbrace{3600 \text{ lbs/ft})}_{\text{soil}} \cos 18.4° \tan 8° = \underline{1613 \text{ lbs/ft}}$$

The yield stress for HDPE is about 2800 psi. This is about 2016 lbs/ft for 60-mil sheet. The applied tensile stress should be keep below this limit by proper anchor trench design. The anchorage should not provide any more resistance than this.

From phone conversation w/ Eric Reed of GSE Lining Technologies regarding typical interface friction values

Some of the stresses due to the soil layer loading are transferred to the lower lining system components. Since the interface friction values for the GCL/textured HDPE and GCL/Soil interfaces are known to be at least **100** % greater than the Geonet/Smooth HDPE value (16° compared to 5°), the loads in the lining system will produce tension only in the HDPE primary lining. The Secondary HDPE lining and GCL will transfer any loading through those layers into the subgrade. The GCL internal shear strength is at least 500 psf.

The minimum vertical loading required to exceed the GCL's 500 psf internal shear strength is shown on the next page.



Assume a worst case condition by using an interface friction value of 30° for the GCL / Textured HDPE interface. This is the highest value reported in the Bentomat Direct Shear Testing Summary dated 6/00. Most values are in the 20° to 25° range.

$$\tau = W \cos 18.4 \tan 30^\circ = 500 \text{ psf}$$

$$W = \frac{500 \text{ psf}}{\cos 18.4 \tan 30} = \underline{912 \text{ psf}}$$

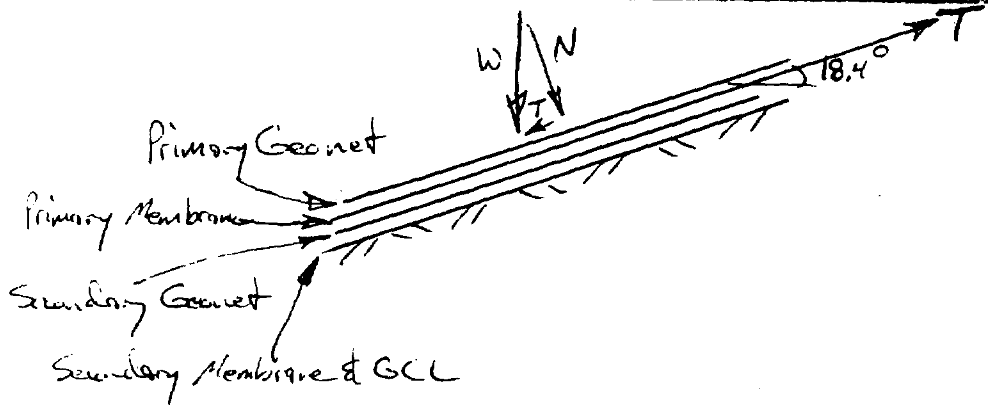
In this worst case, the waste depth would be about $\frac{912 \text{ psf}}{120 \text{ pcf}}$ = 7.5 feet.

This depth of fill is specifically prohibited by the waste filling plan. The only time that this fill depth will occur is in the filled cell areas. The factor of safety for slope stability approaches infinity since the resisting force of the waste fill far exceeds the driving force in this case.

The internal shear strength of the GCL cannot be exceeded under the proposed filling plan that limits the height of wastes on the side slopes to no more than 4 feet above the level of fill within the waste cell.

* The results above show that the secondary membrane & GCL cannot be placed into tension by the proposed loads. All tensile loads will be absorbed by the primary membrane, when any exist.

The total loading on the primary membrane is calculated on the following page.



The range of interface friction values for a Geonet/Smooth HDPE interface are 8° to 12°.

The interface friction between the waste material and the geotextile-faced primary geonet is likely to be at least 75% of the waste material's frictional or cohesive strength. This is substantially higher than the 8° to 12° estimated for the geonet/smooth HDPE interface, therefore no slippage will be assumed between the waste & primary geonet.

Evaluate (2) cases,
1) primary interface @ 12°, secondary interface @ 8°
2) primary interface @ 12°, secondary interface @ 12°

1) Stress transmitted by primary geonet =

$= (8500 \text{ lbs/ft} + 3600 \text{ lbs/ft}) \cos 18.4° \tan 12°$
$= \underline{2440 \text{ lbs/ft}}$

Stress transmitted by secondary geonet to secondary membrane/GCL

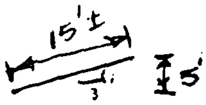
$= (8500 \text{ lbs/ft} + 3600 \text{ lbs/ft}) \cos 18.4° \tan 8°$
$= \underline{1613 \text{ lbs/ft}}$

Tension in Primary membrane

$2440 \text{ lbs/ft} - 1613 \text{ lbs/ft} = \underline{827 \text{ lbs/ft}}$

Stress on Secondary membrane/GCL

$\underline{1613 \text{ lbs/ft}}$ $\qquad \frac{1613 \text{ lbs/ft}}{15'} = \boxed{107\ \cancel{322} \text{ psf} < 50}$ OK



The length of the soil prism used in this analysis is 15'

2) Stress transmitted by Primary Geonet = 2440 lbs/ft

Stress transmitted by Secondary geonet to secondary membrane & GCL = 2440 lbs/ft

Tension in Primary Membrane = 2440 - 2440 = 0 lbs/ft

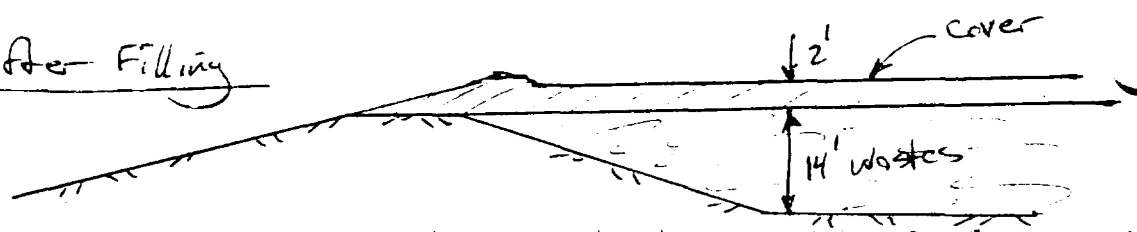
Stress on Secondary Membrane/GCL = 2440 lbs/ft

Stress distributed over contact area = $\frac{2440 \text{ lbs/ft}}{15'}$ = $\boxed{162 \text{ psf}}$

OK

162 << 500 psf limit for GCL internal strength

Stresses After Filling



The cover soils are to be a silty or ~~clayey~~ sand material. The moist unit weight is assumed to be 120 pcf, which is conservative for the material.

The waste material is expected to be a very silty or clayey material. Typical wet unit weights for these materials are between 90 and 110 pcf. This analysis will use 115 pcf to be conservative.

Max. Overburden Stress @ toe of slope

$(14' \times 115 \text{ pcf}) + (2' \times 120 \text{ pcf}) = \underline{1850 \text{ psf}}$

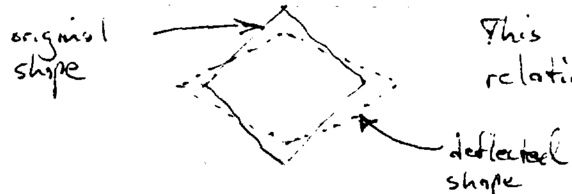
The waste material is expected to consolidate slightly after placement. Evaluate the downslope movement of the wastes due to consolidation.

For any tensile stress to be applied to the lining, the soil on the slope would have to move downslope. That means that a horizontal strain in the soil mass would occur.

Poisson's ratio is a measure of the horizontal & vertical strain relationship:

$$\mu = \frac{\varepsilon_{horizontal}}{\varepsilon_{vertical}}$$

For various soils, the Poisson's ratio falls in the range of 0.2 to 0.4.



This figure shows the relationship for Poisson's ratio

In the case above, consolidation strain would translate to a lateral movement opposing any downslope movement. Additionally, ~~the~~ consolidation theory assumes no lateral spreading. The poisson ratio & consolidation theory both give evidence that lateral movement ~~the~~ downslope due to consolidation is not likely.

Evaluate the state of horizontal stresses in the waste and compare to the driving force of the soil wedge on the side slope

The minimum horizontal stress expected within the wastes can be estimated using the "at-rest" pressure coefficient $(K_o) = \sigma'_h / \sigma'_v$

empirical correlation $= K_o = (1 - \sin\phi)$ where ϕ = soil friction angle

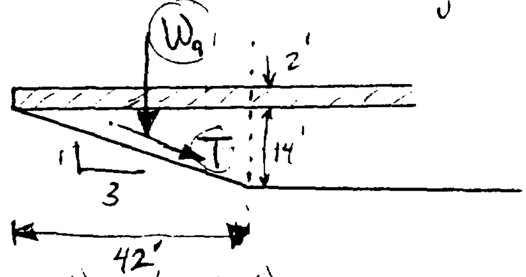
At the toe of slope location, $\sigma'_v \approx$ 1850 psf (from pg 4)

The soil friction angle (ϕ) could range from 0° (undrained) to about 30° (drained)

That shows that K_o ranges from 1.0 to 0.5

Therefore σ_h ranges from 1850 to 925 psf.

The driving force at the toe of slope is calculated below:



$$W_a = \frac{(2' \times 120\,pcf) + (2 \times 120\,pcf) + (14' \times 115\,pcf)}{2} \times 42'$$

$= 1045\,psf \times 42'$

$= \underline{43{,}890\ lbs}$

$T = W_a \sin \beta$ — $\beta = 18.4°$ for 3:1 slope

$= 43{,}890 \sin 18.4$

$= \underline{13854\ lbs}$

The wedge acts on an interface measuring 16' x 1' (unit width)

Soil Wedge Lateral Pressure $= \dfrac{13854\ lbs}{16\ ft^2} = \underline{865\ psf}$

The analysis above neglects any interface friction and also the improvement in the K_o due to waste compaction.

Both of these factors would further improve the conditions. Including the interface friction reduces the lateral pressure. Compaction improves the K_o factor by the following relationship

$$K_{o\,compacted} = K_{o(nc)} \times \sqrt{OCR}$$

where: nc = stands for normally consolidated (uncompacted)

OCR = overconsolidation ratio

Construction compaction routinely achieves OCR's of 2 to 4. This results in the k_o increasing a factor of 1.5 to 2.

URS Greiner Woodward Clyde

Job: Solution Saget	Project No. C-100004051.00	Page ___ of ___	
Description: Lining System Tensile Stresses	Computed by: M. Baumgard	Sheet 7 of 7	Date 10/23/00
	Checked by: R. Haydon		Date 10/25/00

Reference

Summary:

The analyses using either a stress or strain approach indicate that no appreciable movement of the soil mass on the cell slopes will occur.

This shows that consolidation or other conditions will not create additional lining tension once the wastes are in place within the cell.

The lining system components will only endure normal stresses due to the overburden loading. No shear stresses will be created in the lining system after cell filling is complete.

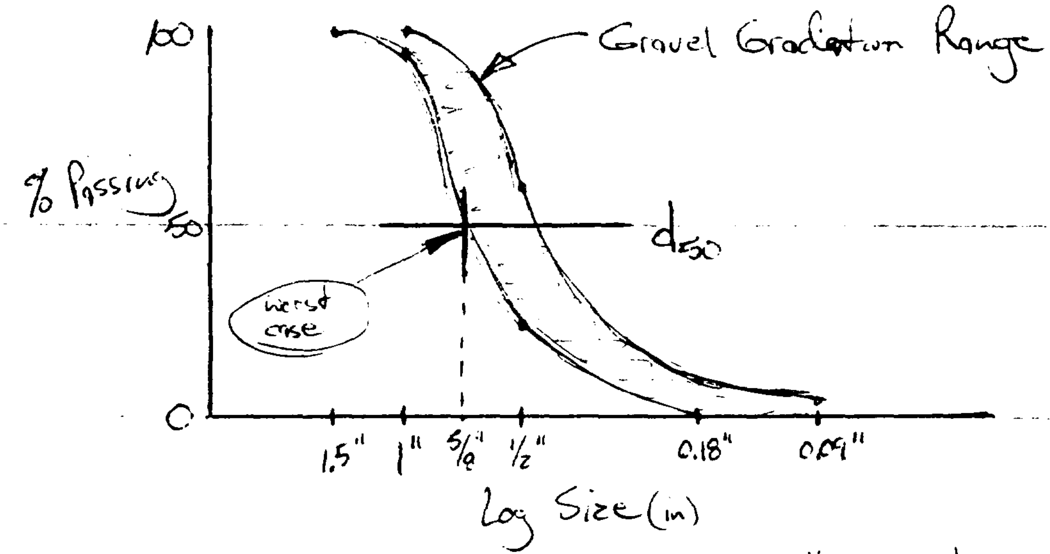
Geotextile Separation Fabric Design

Purpose: Determine requirements for a geotextile separator fabric located between the gravel layer and overlying GCL bedding soil layer beneath the proposal landfill cell.

Assumptions: The gravel fill material will have the following gradation as shown in Section 02200 of the Technical Specifications.

Size	% Passing
1.5"	100
1.0"	95-100
0.5"	25-60
No.4 (0.18")	0-10
No.8 (0.09")	0-5

The gradation is graphically described below



Assume Avg. Stone Size = 5/8" = d_{50}

Burst Resistance

Applicable Equns: $T_{req'd} = \frac{1}{2} p' d_v [f(\varepsilon)]$

and $F.S. = \dfrac{60.6\, p_{test}}{p' d_a}$

where: p' = applied pressure (say 100 psi)

p_{Test} = Mullen Burst test pressure

d_v = 0.33 d_a

d_a = d_{50} = 5/8"

* The applied pressure (100psi) is very conservative since it assumes high pressure truck tires & ~~no~~ reduction due to spreading of the loading through the soil layer.

Assume the F.S. = 2.0

this has units of (mm)

$$2.0 = \frac{60.6\ \rho_{test}}{(100psi)(5/8'')} \longrightarrow 15.8\ mm$$

$$2.0 = \frac{60.6\ \rho_{test}}{(100psi)(15.8\,mm)}$$

$\underline{524_{psi} = \rho_{test}}$ (min) Mullen Burst Str.

<u>Tensile Strength</u> Applicable Eqn : $T_{req} = \rho'(d_v)^2[f(\varepsilon)]$

where : ρ' = applied pressure (100 psi)
d_v = 0.33 d_a
d_a = d_{50} = 5/8" = 15.8 mm
$f(\varepsilon)$ = strain function → 0.52 (assumed)

$$T_{req} = 100psi\left(\frac{5/8''}{3}\right)^2 0.52$$

$= \underline{\cancel{20.5}\ lbs}$ $\underline{2.25\ lbs}$ (init) 11/2/00

use F.S. = 2.0

$T_{allow} = 2.0 \times T_{req}$

$= 2.0 \times \cancel{20.5}\ 2.25$ lbs

$= \underline{\cancel{40.6}\ lbs}$ 4.5 lbs (init) 11/2/00 ult. Grab Strength

<u>Tear Strength (Puncture)</u>

Applicable Eqn : $F_{req} = \rho' d_a^2 S_1 S_2 S_3$

where ρ' = applied pressure (100 psi)
d_a = d_{50} = 5/8" = 15.8 mm
S_1 = protrusion factor = 0.4
S_2 = scale factor = 0.5
S_3 = shape factor = 0.6

URS Greiner Woodward Clyde

Job	Solutia Sauget	Project No.	C100004051.00	Sheet 3 of 4	Page ___ of ___
Description	Gravel Layer / Separator Fabric Design	Computed by	M. Brunagel	Date	10/8/00
		Checked by	C. Reed	Date	11/2/00
				Reference	

$$F_{req} = 100\,psi\,(5/8'')^2\,0.4(0.5)\,0.6$$

$$= \underline{4.7\ lbs}$$

A fabric with 10 lbs puncture strength provides a F.S. of over 2.0.

Summary

The separator fabric between the gravel & GCL bedding layer should have the following minimum properties:

Mullen Burst (ASTM D 3786) = 53 psi
Grab Strength (ASTM D4632) = ~~41~~ lbs 5 lbs
Puncture Strength (ASTM D4833) = 10 lbs

A technical data sheet for an example geotextile product meeting these requirements is attached

The Mirafi 135N product has:

Mullen Burst = 145 psi
Grab Strength = 80 lbs
Puncture Strength = 40 lbs

All the material values greatly exceed the required values. This is one of the lightest fabrics available.

Reference: Designing with Geosynthetics, Koerner, 4th Ed, 1999 pg. 151 – 158.

Gravel Layer Separator Fabric Design M. Brungardt 10/18/00

TC Mirafi *TECHNICAL DATA SHEET*

Mirafi 135N

Mirafi 135N is a nonwoven geotextile composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. 135N is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Grab Tensile Strength	ASTM D 4632	kN (lbs)	0.36 (80)	0.36 (80)
Grab Tensile Elongation	ASTM D 4632	%	50	50
Trapezoid Tear Strength	ASTM D 4533	kN (lbs)	0.13 (30)	0.13 (30)
Mullen Burst Strength	ASTM D 3786	kPa (psi)	1000 (145)	
Puncture Strength	ASTM D 4833	kN (lbs)	0.17 (40)	
Apparent Opening Size (AOS)	ASTM D 4751	mm (U.S. Sieve)	0.300 (50)	
Permittivity	ASTM D 4491	sec^{-1}	2.1	
Permeability	ASTM D 4491	cm/sec	0.23	
Flow Rate	ASTM D 4491	$l/min/m^2$ ($gal/min/ft^2$)	6336 (155)	
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70	

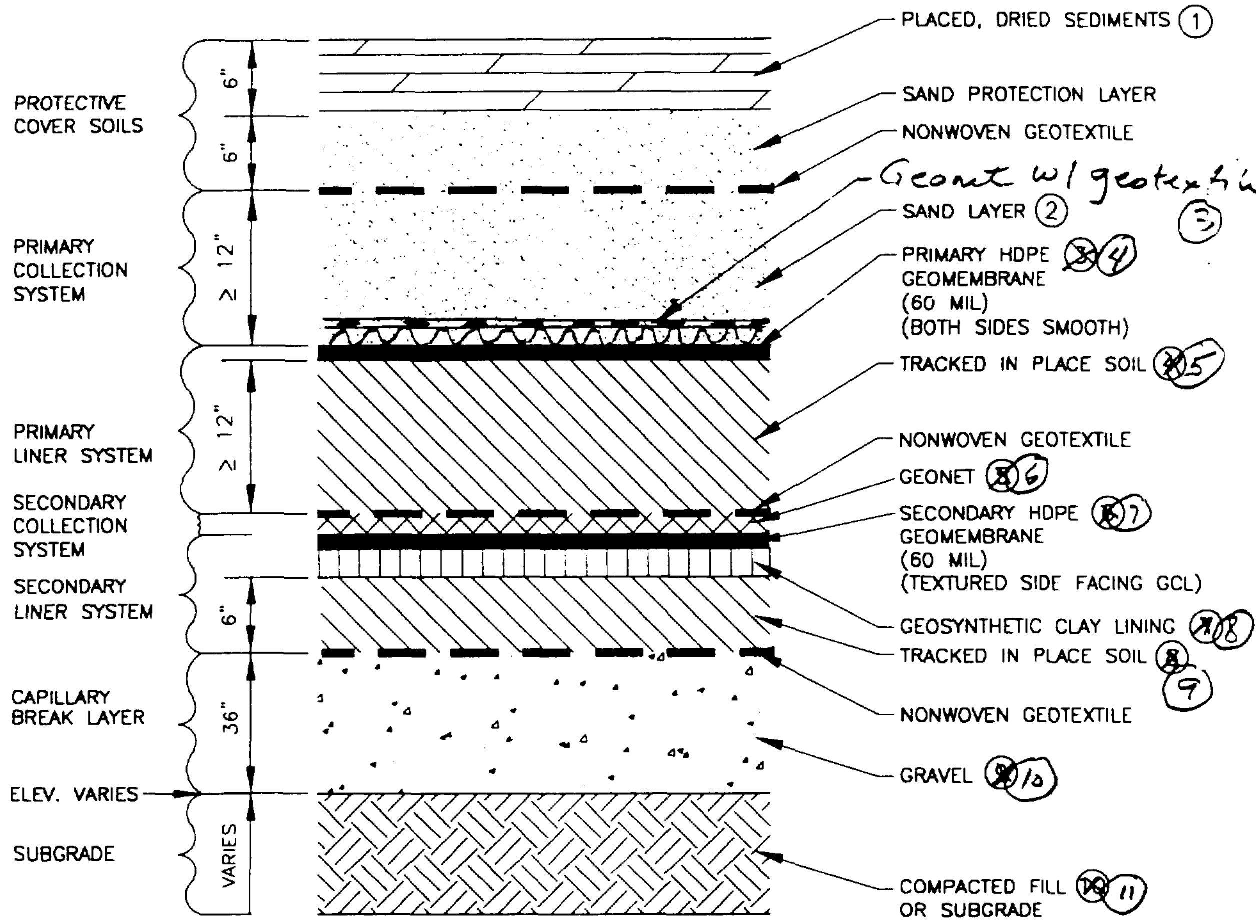
Physical Properties	Test Method	Unit	Typical Value	
Weight	ASTM D 5261	g/m^2 (oz/yd^2)	110 (3.2)	
Thickness	ASTM D 5199	mm (mils)	1.0 (40)	
Roll Dimensions (width x length)	--	m (ft)	3.8 x 110 (12.5 x 360)	4.5 x 110 (15 x 360)
Roll Area	--	m^2 (yd^2)	418 (500)	502 (600)
Estimated Roll Weight	--	kg (lb)	55 (121)	65 (144)

DISCLAIMER: TC Mirafi warrants our products to be free from defects in material and workmanship when delivered to TC Mirafi's customers and that our products meet our published specifications. Contact your local TC Mirafi Representative for detailed product specification and warranty information.

135N.DOC
Revision 3
Date: March 1, 2000

HELP Evaluation

HELP EVALUATION DIAGRAM
CONSTRUCTION CASE
PAGE 1 OF 1



LEGEND

6 HELP ANALYSIS LAYER NO.

A BOTTOM LINER SYSTEM DETAIL

C1.4 | C1.6

N.T.S.

NOTES
1. NOT FOR CONSTRUCTION
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS

PREPARED FOR: SOLUTIA	*Drawn: R. HAYDEN*	*PROJECT NAME* SOLUTIA INC. SAUGET AREA 1	FIGURE 4-1
URSGWC JOB NUMBER: C100003899.00	*Design: M. BRUNGARD*		
URS Greiner Woodward Clyde A Division of URS Corporation 7650 W. Courtney Campbell Causeway Tampa, Florida 33607-1462 Tel: 813.286.1711 Fax: 813.287.8591	*Checked: G. WANTLAND*	*DRAWING TITLE* BOTTOM LINER SYSTEM DETAIL	
	Date: OCT. 30, 2000		

S:\C10000\4000\EPA COMMENT RESPONSE\REVISED FIGURES\C1.6_LINRDETL_REV.DWG 11/01/00 11:02

CONSTRUCTION CASE

```
****************************************************************************
****************************************************************************
**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**             HELP MODEL VERSION 3.07   (1 NOVEMBER 1997)                **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                  USAE WATERWAYS EXPERIMENT STATION                     **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\DATA4.D4
TEMPERATURE DATA FILE:        C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\DATA10.D10
OUTPUT DATA FILE:             C:\HELP3\case2.OUT


TIME:  17: 2      DATE:   2/22/2001


****************************************************************************

     TITLE:  Sauget

****************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   8
           THICKNESS                    =     80.00    INCHES
           POROSITY                     =      0.4630 VOL/VOL
           FIELD CAPACITY               =      0.2320 VOL/VOL
           WILTING POINT                =      0.1160 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.2585 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =     18.00    INCHES
```

```
POROSITY                    =       0.4170 VOL/VOL
FIELD CAPACITY              =       0.0450 VOL/VOL
WILTING POINT               =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.1332 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                     LAYER  3
                     --------

           TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =       0.25    INCHES
POROSITY                    =       0.8500 VOL/VOL
FIELD CAPACITY              =       0.0100 VOL/VOL
WILTING POINT               =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.0353 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =    5.00000000000      CM/SEC
SLOPE                       =       2.00    PERCENT
DRAINAGE LENGTH             =     275.0     FEET


                     LAYER  4
                     --------

           TYPE 4 - FLEXIBLE MEMBRANE LINER
             MATERIAL TEXTURE NUMBER  35
THICKNESS                   =       0.06    INCHES
POROSITY                    =       0.0000 VOL/VOL
FIELD CAPACITY              =       0.0000 VOL/VOL
WILTING POINT               =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =       0.00    HOLES/ACRE
FML INSTALLATION DEFECTS    =       0.00    HOLES/ACRE
FML PLACEMENT QUALITY       =  1 - PERFECT


                     LAYER  5
                     --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   8
THICKNESS                   =      12.00    INCHES
POROSITY                    =       0.4630 VOL/VOL
FIELD CAPACITY              =       0.2320 VOL/VOL
WILTING POINT               =       0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.369999994000E-03 CM/SEC


                     LAYER  6
                     --------

           TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =       0.25    INCHES
POROSITY                    =       0.8500 VOL/VOL
FIELD CAPACITY              =       0.0100 VOL/VOL
```

WILTING POINT	=	0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	5.00000000000 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	275.0 FEET

LAYER 7

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	0.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	1 - PERFECT

LAYER 8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08 CM/SEC

LAYER 9

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03 CM/SEC

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	36.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320 VOL/VOL

EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	275.0	FEET

LAYER 11

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4630	VOL/VOL
FIELD CAPACITY	=	0.2320	VOL/VOL
WILTING POINT	=	0.1160	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4630	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	90.20	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.214	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.260	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.320	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	34.159	INCHES
TOTAL INITIAL WATER	=	34.159	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	98	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA FOR COLUMBIA MISSOURI
WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.45 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1974

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.58	2.70	3.03	3.55	7.75	5.89
	1.43	7.57	1.77	1.20	3.81	1.65
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.677	1.676	2.599	3.260	5.070	5.869
	2.037	4.012	3.009	1.337	1.826	1.175
LATERAL DRAINAGE COLLECTED	0.2382	0.6435	1.7824	1.8527	0.9871	0.7285
FROM LAYER 3	2.1501	0.9906	0.6839	0.2311	0.5384	0.5779
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.004	0.011	0.028	0.030	0.015	0.012
TOP OF LAYER 4	0.034	0.016	0.011	0.004	0.009	0.009
STD. DEVIATION OF DAILY	0.002	0.012	0.017	0.007	0.003	0.011
HEAD ON TOP OF LAYER 4	0.009	0.003	0.002	0.003	0.001	0.001

AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.93	159465.828	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	32.548	118150.266	74.09
DRAINAGE COLLECTED FROM LAYER 3	11.4042	41397.211	25.96
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0151		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	-0.022	-81.561	-0.05
SOIL WATER AT START OF YEAR	36.943	134101.703	
SOIL WATER AT END OF YEAR	36.920	134020.141	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.092	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1975

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.38	2.96	3.23	4.29	4.00	3.83
	0.55	8.18	5.60	2.06	3.57	2.48
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.666	0.360	2.016	3.078	4.464	4.189
	1.582	3.749	4.578	2.377	1.670	0.765
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.2549	0.2092	2.2136	2.2225	1.5822	1.1852
	0.7254	0.3690	0.4487	0.9897	1.0306	0.7123
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 4	0.004	0.004	0.035	0.036	0.025	0.019
	0.011	0.006	0.007	0.015	0.017	0.011
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 4	0.002	0.001	0.045	0.012	0.009	0.004
	0.004	0.001	0.004	0.008	0.003	0.004
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT

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PRECIPITATION	44.13	160191.891	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	29.494	107064.781	66.84
DRAINAGE COLLECTED FROM LAYER 3	11.9434	43354.570	27.06
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0158		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	2.692	9772.477	6.10
SOIL WATER AT START OF YEAR	36.920	134020.141	
SOIL WATER AT END OF YEAR	38.866	141083.391	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.746	2709.233	1.69
ANNUAL WATER BUDGET BALANCE	0.0000	0.051	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1976

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.94	2.36	4.39	2.21	3.68	1.79
	0.24	0.21	0.47	6.12	0.88	0.59
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.760	1.403	2.593	3.378	3.573	2.883
	0.741	0.212	0.170	2.086	1.667	0.475
LATERAL DRAINAGE COLLECTED	0.4457	1.3999	1.3827	1.5173	0.8385	0.5523
FROM LAYER 3	0.4591	0.3410	0.2571	0.2153	0.2263	0.1324
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 4	0.007	0.023	0.022	0.025	0.013	0.009
	0.007	0.005	0.004	0.003	0.004	0.002
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 4	0.007	0.009	0.011	0.004	0.002	0.001
	0.001	0.000	0.000	0.001	0.001	0.001
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.88	86684.406	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	19.942	72388.672	83.51
DRAINAGE COLLECTED FROM LAYER 3	7.7675	28196.082	32.53
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0104		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000002	0.009	0.00

AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	-3.829	-13900.345	-16.04
SOIL WATER AT START OF YEAR	38.866	141083.391	
SOIL WATER AT END OF YEAR	35.746	129757.461	
SNOW WATER AT START OF YEAR	0.746	2709.233	3.13
SNOW WATER AT END OF YEAR	0.037	134.817	0.16
ANNUAL WATER BUDGET BALANCE	0.0000	-0.011	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1977

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.44	1.17	3.70	2.52	4.49	5.24
	1.62	2.26	6.66	3.68	2.16	1.55
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.347	0.936	2.330	3.471	3.670	4.693
	3.754	1.135	3.967	2.194	1.685	0.557
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.0156	0.3036	0.3778	0.3293	0.1328	0.6209
	0.7657	0.5649	0.3979	0.3702	0.3010	1.3352
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 4	0.000	0.005	0.006	0.005	0.002	0.010
	0.012	0.009	0.006	0.006	0.005	0.021
STD. DEVIATION OF DAILY	0.001	0.001	0.002	0.001	0.002	0.004

HEAD ON TOP OF LAYER 4	0.002	0.001	0.001	0.001	0.006	0.003
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	36.49	132458.672	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	28.740	104326.687	78.76
DRAINAGE COLLECTED FROM LAYER 3	5.5149	20019.197	15.11
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0073		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	2.235	8112.832	6.12
SOIL WATER AT START OF YEAR	35.746	129757.461	
SOIL WATER AT END OF YEAR	38.018	138005.109	
SNOW WATER AT START OF YEAR	0.037	134.817	0.10
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.062	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.70	1.51	5.50	5.00	7.57	2.50
	4.56	2.01	1.06	1.78	3.24	1.64
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.259	0.479	2.891	3.881	5.841	3.078
	5.503	1.262	1.296	1.721	1.350	1.099
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.8385	0.5587	0.4321	1.7774	2.5462	2.0197
	0.9710	0.6231	0.4298	0.3270	0.2478	0.2114
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 4	0.013	0.010	0.007	0.029	0.040	0.033
	0.015	0.010	0.007	0.005	0.004	0.003
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 4	0.002	0.001	0.002	0.021	0.019	0.009
	0.003	0.001	0.001	0.000	0.000	0.001
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.07	134564.062	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	28.659	104032.789	77.31
DRAINAGE COLLECTED FROM LAYER 3	10.9828	39867.512	29.63
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0146		
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	-2.572	-9336.217	-6.94
SOIL WATER AT START OF YEAR	38.018	138005.109	
SOIL WATER AT END OF YEAR	35.446	128668.891	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.033	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.01	2.14	3.97	3.51	5.50	3.85
	1.68	4.05	3.11	2.97	2.73	1.58
STD. DEVIATIONS	1.37	0.77	1.00	1.17	2.00	1.74
	1.71	3.59	2.82	1.99	1.21	0.67
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

EVAPOTRANSPIRATION

TOTALS	0.542	0.971	2.486	3.414	4.524	4.142
	2.724	2.074	2.604	1.943	1.640	0.814
STD. DEVIATIONS	0.223	0.570	0.329	0.300	0.958	1.225
	1.903	1.700	1.841	0.415	0.175	0.314

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.3586	0.6230	1.2377	1.5398	1.2174	1.0213
	1.0143	0.5777	0.4435	0.4267	0.4688	0.5939
STD. DEVIATIONS	0.3086	0.4694	0.8152	0.7222	0.9044	0.6103
	0.6606	0.2609	0.1540	0.3214	0.3377	0.4804

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 10

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0056	0.0106	0.0194	0.0249	0.0191	0.0165
	0.0159	0.0090	0.0072	0.0067	0.0076	0.0093

STD. DEVIATIONS	0.0048	0.0078	0.0128	0.0117	0.0142	0.0099
	0.0103	0.0041	0.0025	0.0050	0.0055	0.0075

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 11

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	37.10	(8.234)	134673.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	27.877	(4.7107)	101192.64	75.140
LATERAL DRAINAGE COLLECTED FROM LAYER 3	9.52257	(2.76923)	34566.914	25.66730
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.013	(0.004)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00000	(0.00000)	0.008	0.00001
AVERAGE HEAD ON TOP OF LAYER 7	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000	(0.00000)	0.008	0.00001
AVERAGE HEAD ON TOP OF LAYER 11	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.299	(2.8755)	-1086.56	-0.807

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	3.80	13794.000
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.25880	939.45331
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 4	0.126	
MAXIMUM HEAD ON TOP OF LAYER 4	0.247	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	4.7 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.00000	0.00003
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 7	0.000	
MAXIMUM HEAD ON TOP OF LAYER 7	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 10	0.00000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 11	0.000	
MAXIMUM HEAD ON TOP OF LAYER 11	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 10 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	2.64	9588.3516

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4630
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1160

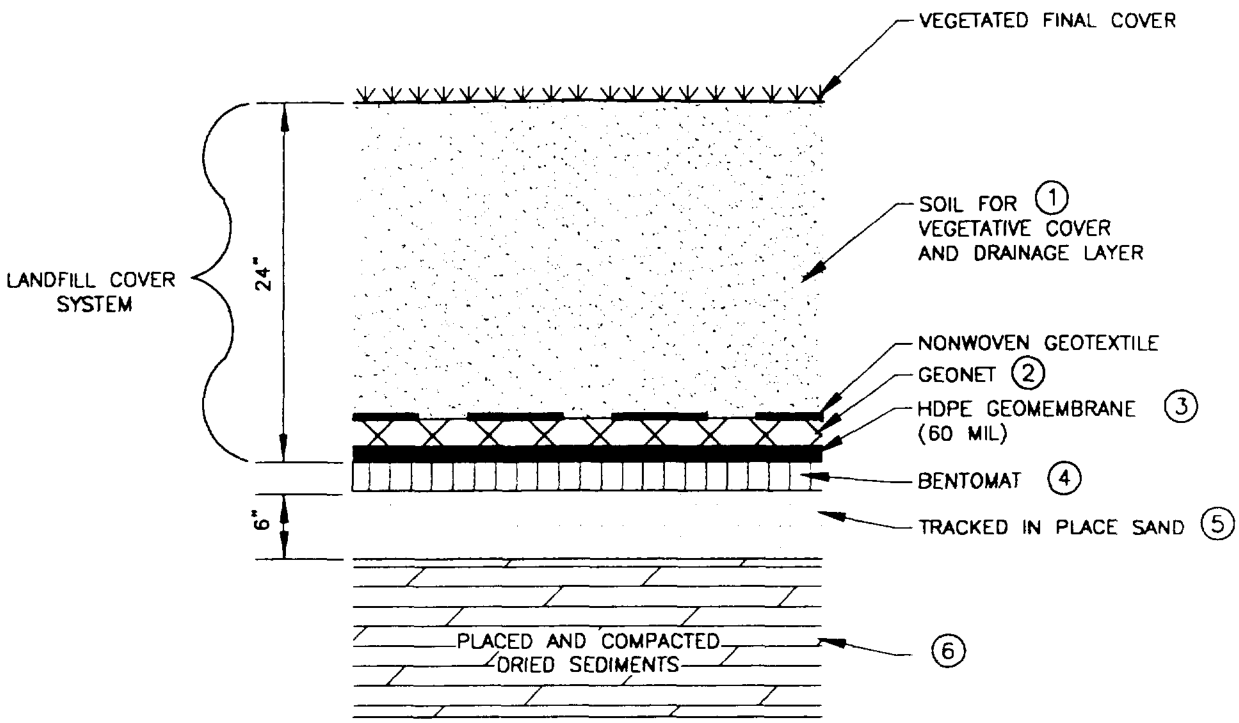
*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	19.2644	0.2408
2	2.3180	0.1288
3	0.0056	0.0222
4	0.0000	0.0000
5	2.7840	0.2320
6	0.0025	0.0100
7	0.0000	0.0000
8	0.1875	0.7500
9	1.3920	0.2320
10	1.1520	0.0320
11	5.5560	0.4630
SNOW WATER	0.000	

HELP EVALUATION DIAGRAM
CLOSED LANDFILL CASE
PAGE 1 OF 12



LEGEND

7 HELP ANALYSIS LAYER NO.

THICKNESSES SHOWN ARE COMPACTED THICKNESSES

NOT FOR CONSTRUCTION

PREPARED FOR: SOLUTIA	Drawn: W. WEBER	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE 5-2
URSGWC JOB NUMBER: C100003899.00	Design: GARY WANTLAND		
URS Greiner Woodward Clyde A Division of URS Corporation 7650 W. Courtney Campbell Causeway Tampa, Florida 33607-1462 Tel: 813.286.1711 Fax: 813.287.8591	Checked: GARY WANTLAND	DRAWING TITLE **COVER SYSTEM DETAIL**	
	Date: JUNE 20, 2000		

J:\NEW FIGURES\PG1_CLOLNOF.DWG 01/22/01 15:24

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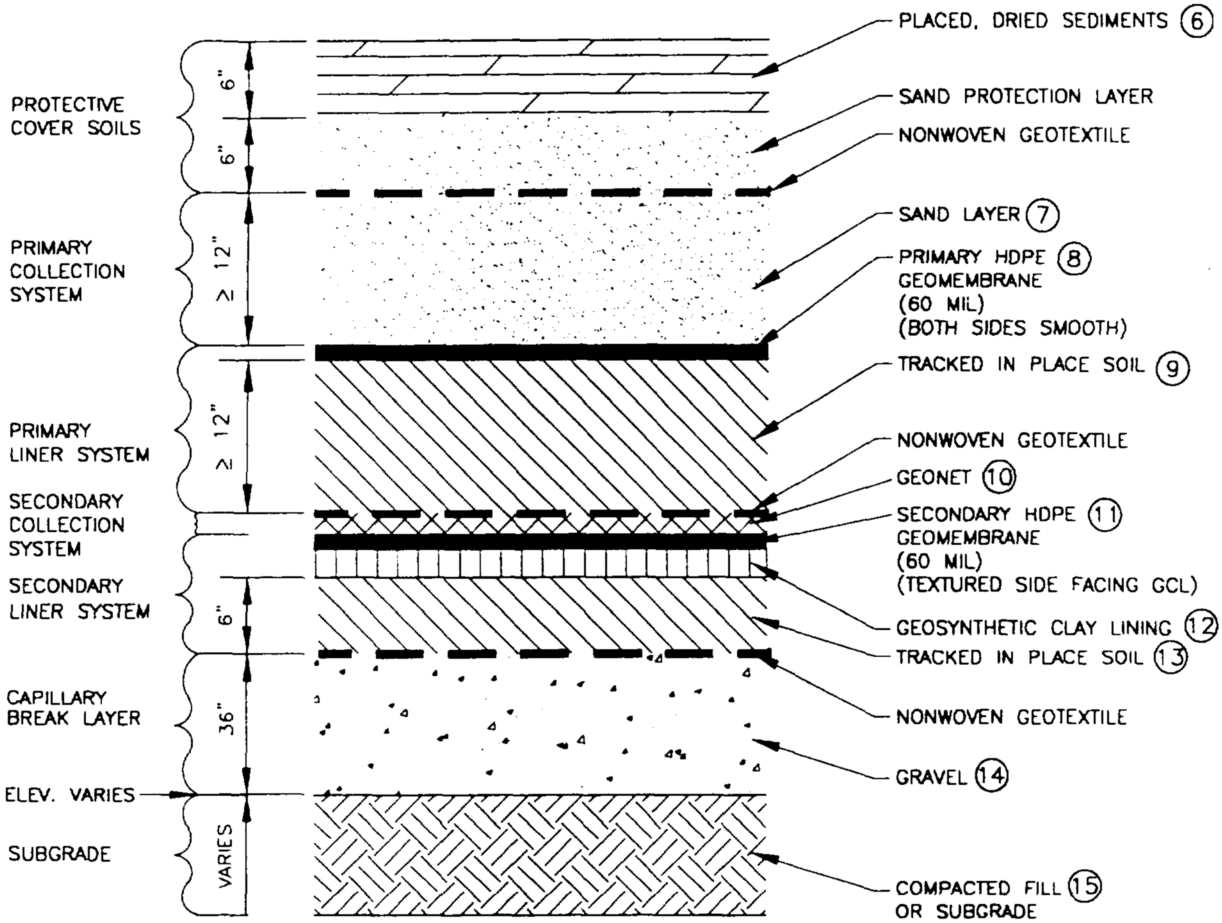
HELP EVALUATION DIAGRAM

~~CONSTRUCTION~~ CASE - CLOSED LANDFILL

PAGE 2 OF 2



LEGEND

6 HELP ANALYSIS LAYER NO.

A BOTTOM LINER SYSTEM DETAIL

C1.4 | C1.6

N.T.S.

NOTES
1. NOT FOR CONSTRUCTION
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS

S:\C10000\4000\EPA COMMENT RESPONSE\REVISED FIGURES\C1.8_LINRDETL_REV.DWG 11/01/00 11:02

PREPARED FOR: SOLUTIA	Drawn: R. HAYDEN	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE 4-1
URSGWC JOB NUMBER: C100003899.00	Design: M. BRUNGARD		
URS Greiner Woodward Clyde A Division of URS Corporation 7650 W. Courtney Campbell Causeway Tampa, Florida 33607-1462 Tel: 813.286.1711 Fax: 813.287.8591	Checked: G. WANTLAND	DRAWING TITLE BOTTOM LINER SYSTEM DETAIL	
	Date: OCT. 30, 2000		

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******************************************************************************
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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\SAUGETP.D4
TEMPERATURE DATA FILE:       C:\HELP3\SAUGETT.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\SAUGETR.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\SAUGETE.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\SAUGETS.D10
OUTPUT DATA FILE:            C:\HELP3\SAUGET.OUT


TIME:  16:21      DATE:   5/ 5/2000


******************************************************************************

     TITLE:  SOLUTIA SAUGET LANDFILL

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   8
           THICKNESS                    =      24.00   INCHES
           POROSITY                     =       0.4630 VOL/VOL
           FIELD CAPACITY               =       0.2320 VOL/VOL
           WILTING POINT                =       0.1160 VOL/VOL
           INITIAL SOIL WATER CONTENT   =       0.2856 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1193	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	340.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	3.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	168.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03 CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	275.0 FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	3.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 9

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03 CM/SEC

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	275.0	FEET

LAYER 11

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	3.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 12

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 13

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4630	VOL/VOL
FIELD CAPACITY	=	0.2320	VOL/VOL
WILTING POINT	=	0.1160	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03	CM/SEC

LAYER 14

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	36.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	275.0	FEET

LAYER 15

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4630	VOL/VOL
FIELD CAPACITY	=	0.2320	VOL/VOL
WILTING POINT	=	0.1160	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4630	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 341. FEET.

SCS RUNOFF CURVE NUMBER	=	79.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	2.910	ACRES
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.572	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.260	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.320	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	58.201	INCHES
TOTAL INITIAL WATER	=	58.201	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.45 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	98
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	20.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.45 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.65	323765.125	100.00
RUNOFF	0.024	251.910	0.08
EVAPOTRANSPIRATION	27.545	290968.156	89.87
DRAINAGE COLLECTED FROM LAYER 2	3.0806	32540.881	10.05
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.011	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0017		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.011	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.004	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	0.000	4.110	0.00
SOIL WATER AT START OF YEAR	60.985	644200.000	
SOIL WATER AT END OF YEAR	60.985	644204.125	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.036	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	39.59	418201.062	100.00
RUNOFF	3.480	36760.812	8.79
EVAPOTRANSPIRATION	27.592	291460.625	69.69
DRAINAGE COLLECTED FROM LAYER 2	9.8713	104273.672	24.93
PERC./LEAKAGE THROUGH LAYER 4	0.000005	0.050	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0191		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.006	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000004	0.044	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.029	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.016	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.016	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-1.353	-14294.126	-3.42
SOIL WATER AT START OF YEAR	60.985	644204.125	
SOIL WATER AT END OF YEAR	59.632	629910.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.030	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.44	374363.437	100.00
RUNOFF	0.344	3628.731	0.97
EVAPOTRANSPIRATION	27.070	285946.219	76.38
DRAINAGE COLLECTED FROM LAYER 2	6.7548	71352.523	19.06
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.015	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0039		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.015	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.007	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.008	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.008	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	1.272	13435.970	3.59
SOIL WATER AT START OF YEAR	59.632	629910.000	
SOIL WATER AT END OF YEAR	60.645	640606.375	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.259	2739.613	0.73
ANNUAL WATER BUDGET BALANCE	0.0000	-0.032	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.22	361476.062	100.00
RUNOFF	0.442	4664.964	1.29
EVAPOTRANSPIRATION	28.668	302832.719	83.78
DRAINAGE COLLECTED FROM LAYER 2	4.3833	46302.277	12.81
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.017	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0051		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.016	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.007	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.009	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.009	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	0.727	7676.210	2.12
SOIL WATER AT START OF YEAR	60.645	640606.375	
SOIL WATER AT END OF YEAR	61.219	646672.625	
SNOW WATER AT START OF YEAR	0.259	2739.613	0.76
SNOW WATER AT END OF YEAR	0.412	4349.573	1.20
ANNUAL WATER BUDGET BALANCE	0.0000	-0.136	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.60	354926.844	100.00
RUNOFF	0.238	2519.239	0.71
EVAPOTRANSPIRATION	30.228	319310.469	89.97
DRAINAGE COLLECTED FROM LAYER 2	4.6845	49484.230	13.94
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.020	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0051		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.019	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.010	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.010	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.010	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-1.551	-16387.256	-4.62
SOIL WATER AT START OF YEAR	61.219	646672.625	
SOIL WATER AT END OF YEAR	60.079	634634.937	
SNOW WATER AT START OF YEAR	0.412	4349.573	1.23
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.129	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.69	377004.250	100.00
RUNOFF	0.389	4107.287	1.09
EVAPOTRANSPIRATION	28.841	304651.875	80.81
DRAINAGE COLLECTED FROM LAYER 2	6.8004	71834.617	19.05
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.025	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0098		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.023	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.012	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.011	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.011	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-0.340	-3589.630	-0.95
SOIL WATER AT START OF YEAR	60.079	634634.937	
SOIL WATER AT END OF YEAR	59.739	631045.312	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.064	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	28.47	300737.156	100.00
RUNOFF	1.550	16368.519	5.44
EVAPOTRANSPIRATION	22.055	232976.469	77.47
DRAINAGE COLLECTED FROM LAYER 2	4.0334	42605.801	14.17
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.015	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0044		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.014	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.007	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	0.832	8786.417	2.92
SOIL WATER AT START OF YEAR	59.739	631045.312	
SOIL WATER AT END OF YEAR	60.571	639831.687	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.070	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.71	398342.094	100.00
RUNOFF	0.534	5639.037	1.42
EVAPOTRANSPIRATION	30.167	318665.687	80.00
DRAINAGE COLLECTED FROM LAYER 2	7.3622	77769.023	19.52
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.019	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0050		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.018	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.006	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.012	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.012	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-0.353	-3731.713	-0.94
SOIL WATER AT START OF YEAR	60.571	639831.687	
SOIL WATER AT END OF YEAR	60.218	636100.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.023	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.95	369187.344	100.00
RUNOFF	3.241	34231.441	9.27
EVAPOTRANSPIRATION	24.835	262335.969	71.06
DRAINAGE COLLECTED FROM LAYER 2	5.8833	62146.891	16.83
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.026	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0104		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.023	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.014	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.009	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.009	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	0.991	10473.118	2.84
SOIL WATER AT START OF YEAR	60.218	636100.000	
SOIL WATER AT END OF YEAR	60.726	641470.937	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.483	5102.172	1.38
ANNUAL WATER BUDGET BALANCE	0.0000	-0.111	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.23	340455.219	100.00
RUNOFF	1.051	11100.992	3.26
EVAPOTRANSPIRATION	25.951	274127.687	80.52
DRAINAGE COLLECTED FROM LAYER 2	5.2335	55283.199	16.24
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.022	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0082		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.020	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.011	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.010	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.010	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-0.005	-56.613	-0.02
SOIL WATER AT START OF YEAR	60.726	641470.937	
SOIL WATER AT END OF YEAR	60.860	642877.375	
SNOW WATER AT START OF YEAR	0.483	5102.172	1.50
SNOW WATER AT END OF YEAR	0.345	3639.115	1.07
ANNUAL WATER BUDGET BALANCE	0.0000	-0.100	0.00

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ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.54	343729.750	100.00
RUNOFF	1.345	14207.578	4.13
EVAPOTRANSPIRATION	25.917	273768.187	79.65
DRAINAGE COLLECTED FROM LAYER 2	4.6166	48766.336	14.19
PERC./LEAKAGE THROUGH LAYER 4	0.000004	0.039	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0170		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.006	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000003	0.033	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.026	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	0.662	6987.647	2.03
SOIL WATER AT START OF YEAR	60.860	642877.375	
SOIL WATER AT END OF YEAR	60.669	640864.187	
SNOW WATER AT START OF YEAR	0.345	3639.115	1.06
SNOW WATER AT END OF YEAR	1.197	12639.980	3.68
ANNUAL WATER BUDGET BALANCE	0.0000	-0.025	0.00

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ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.65	292075.344	100.00
RUNOFF	0.803	8482.851	2.90
EVAPOTRANSPIRATION	26.174	276484.312	94.66
DRAINAGE COLLECTED FROM LAYER 2	3.3134	34999.957	11.98
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.019	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0063		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.018	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.011	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-2.640	-27891.752	-9.55
SOIL WATER AT START OF YEAR	60.669	640864.187	
SOIL WATER AT END OF YEAR	59.210	625454.750	
SNOW WATER AT START OF YEAR	1.197	12639.980	4.33
SNOW WATER AT END OF YEAR	0.015	157.661	0.05
ANNUAL WATER BUDGET BALANCE	0.0000	-0.067	0.00

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ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.42	289645.687	100.00
RUNOFF	0.020	215.640	0.07
EVAPOTRANSPIRATION	26.420	279086.687	96.35
DRAINAGE COLLECTED FROM LAYER 2	0.2858	3018.781	1.04
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0002		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000000	0.005	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	0.693	7324.417	2.53
SOIL WATER AT START OF YEAR	59.210	625454.750	
SOIL WATER AT END OF YEAR	59.898	632723.750	
SNOW WATER AT START OF YEAR	0.015	157.661	0.05
SNOW WATER AT END OF YEAR	0.020	213.040	0.07
ANNUAL WATER BUDGET BALANCE	0.0000	0.165	0.00

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ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.75	293131.625	100.00
RUNOFF	0.399	4214.822	1.44
EVAPOTRANSPIRATION	22.685	239623.437	81.75
DRAINAGE COLLECTED FROM LAYER 2	3.8460	40626.520	13.86
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.009	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0021		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.009	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.006	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.006	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	0.820	8666.734	2.96
SOIL WATER AT START OF YEAR	59.898	632723.750	
SOIL WATER AT END OF YEAR	60.704	641234.625	
SNOW WATER AT START OF YEAR	0.020	213.040	0.07
SNOW WATER AT END OF YEAR	0.035	368.901	0.13
ANNUAL WATER BUDGET BALANCE	0.0000	0.095	0.00

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ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	31.54	333166.594	100.00
RUNOFF	1.570	16580.018	4.98
EVAPOTRANSPIRATION	25.083	264957.844	79.53
DRAINAGE COLLECTED FROM LAYER 2	6.0841	64268.660	19.29
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.023	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0089		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.021	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.012	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.008	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.008	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-1.197	-12639.977	-3.79
SOIL WATER AT START OF YEAR	60.704	641234.625	
SOIL WATER AT END OF YEAR	59.542	628963.562	
SNOW WATER AT START OF YEAR	0.035	368.901	0.11
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.023	0.00

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ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.11	360314.187	100.00
RUNOFF	2.413	25487.684	7.07
EVAPOTRANSPIRATION	27.522	290723.000	80.69
DRAINAGE COLLECTED FROM LAYER 2	4.3051	45476.145	12.62
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.018	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0059		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.017	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.009	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.008	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.008	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-0.130	-1372.596	-0.38
SOIL WATER AT START OF YEAR	59.542	628963.562	
SOIL WATER AT END OF YEAR	59.412	627591.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.073	0.00

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ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.61	238836.250	100.00
RUNOFF	2.097	22146.135	9.27
EVAPOTRANSPIRATION	18.154	191765.969	80.29
DRAINAGE COLLECTED FROM LAYER 2	2.1828	23057.705	9.65
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.013	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0047		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.012	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.007	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000000	0.004	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000000	0.004	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	0.177	1866.417	0.78
SOIL WATER AT START OF YEAR	59.412	627591.000	
SOIL WATER AT END OF YEAR	59.122	624527.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.467	4930.187	2.06
ANNUAL WATER BUDGET BALANCE	0.0000	0.011	0.00

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ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.85	442074.156	100.00
RUNOFF	2.541	26839.400	6.07
EVAPOTRANSPIRATION	31.232	329914.156	74.63
DRAINAGE COLLECTED FROM LAYER 2	7.0407	74373.445	16.82
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.022	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0090		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.016	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.008	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.007	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	1.036	10946.960	2.48
SOIL WATER AT START OF YEAR	59.122	624527.187	
SOIL WATER AT END OF YEAR	60.625	640404.375	
SNOW WATER AT START OF YEAR	0.467	4930.187	1.12
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.171	0.00

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.48	353659.250	100.00
RUNOFF	0.897	9474.285	2.68
EVAPOTRANSPIRATION	27.777	293418.875	82.97
DRAINAGE COLLECTED FROM LAYER 2	5.0123	52946.508	14.97
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.014	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0027		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000002	0.018	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.008	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.010	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.010	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-0.206	-2180.405	-0.62
SOIL WATER AT START OF YEAR	60.625	640404.375	
SOIL WATER AT END OF YEAR	60.419	638223.937	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.028	0.00

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ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.65	397708.281	100.00
RUNOFF	0.692	7312.188	1.84
EVAPOTRANSPIRATION	27.836	294039.187	73.93
DRAINAGE COLLECTED FROM LAYER 2	9.2266	97463.133	24.51
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.031	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0122		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000003	0.029	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 10	0.0000	0.017	0.00
PERC./LEAKAGE THROUGH LAYER 12	0.000001	0.012	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
DRAINAGE COLLECTED FROM LAYER 14	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 15	0.000001	0.012	0.00
AVG. HEAD ON TOP OF LAYER 15	0.0000		
CHANGE IN WATER STORAGE	-0.105	-1106.402	-0.28
SOIL WATER AT START OF YEAR	60.419	638223.937	
SOIL WATER AT END OF YEAR	60.314	637117.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.118	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.49	2.05	2.93	3.43	3.20	4.51
	3.26	2.50	2.86	2.21	2.17	2.34
STD. DEVIATIONS	0.79	1.05	0.90	1.42	1.74	2.24
	2.07	1.27	1.44	1.28	1.58	1.10
RUNOFF						
TOTALS	0.210	0.405	0.382	0.007	0.019	0.093
	0.038	0.000	0.006	0.005	0.019	0.017
STD. DEVIATIONS	0.312	0.453	0.749	0.021	0.048	0.208
	0.102	0.000	0.022	0.023	0.043	0.031
EVAPOTRANSPIRATION						
TOTALS	0.488	0.698	2.271	3.384	3.518	4.759
	3.446	2.509	2.144	1.503	1.100	0.768
STD. DEVIATIONS	0.254	0.439	0.509	0.858	1.060	1.463
	1.597	1.156	1.029	0.309	0.367	0.204
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.3745	0.7412	1.5196	0.6086	0.3566	0.2508
	0.0648	0.0229	0.0108	0.1243	0.3407	0.7852
STD. DEVIATIONS	0.4922	1.0051	0.8313	0.5815	0.6077	0.5925
	0.1480	0.1002	0.0417	0.4369	0.7828	1.0015
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 10

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 12

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 14

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 15

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0024	0.0202	0.0366	0.0046	0.0029	0.0022
	0.0004	0.0001	0.0001	0.0021	0.0050	0.0082
STD. DEVIATIONS	0.0032	0.0307	0.0447	0.0058	0.0063	0.0060
	0.0010	0.0006	0.0003	0.0086	0.0137	0.0195

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 11

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 15

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.96 (4.646)	348140.0	100.00
RUNOFF	1.203 (1.0512)	12711.68	3.651
EVAPOTRANSPIRATION	26.588 (3.0465)	280852.87	80.672
LATERAL DRAINAGE COLLECTED FROM LAYER 2	5.20003 (2.28190)	54929.516	15.77800
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000 (0.00000)	0.021	0.00001
AVERAGE HEAD ON TOP OF LAYER 3	0.007 (0.005)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00000 (0.00000)	0.002	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00000 (0.00000)	0.019	0.00001
AVERAGE HEAD ON TOP OF LAYER 8	0.000 (0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.00000 (0.00000)	0.011	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.00000 (0.00000)	0.008	0.00000
AVERAGE HEAD ON TOP OF LAYER 11	0.000 (0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 14	0.00000 (0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 15	0.00000 (0.00000)	0.008	0.00000
AVERAGE HEAD ON TOP OF LAYER 15	0.000 (0.000)		
CHANGE IN WATER STORAGE	-0.034 (1.0117)	-354.12	-0.102

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	3.44	36337.754
RUNOFF	1.265	13359.7051
DRAINAGE COLLECTED FROM LAYER 2	0.98498	10404.58690
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000002	0.01724
AVERAGE HEAD ON TOP OF LAYER 3	2.886	
MAXIMUM HEAD ON TOP OF LAYER 3	4.136	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	30.6 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00031
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00113
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 10	0.00000	0.00103
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.000000	0.00007
AVERAGE HEAD ON TOP OF LAYER 11	0.000	
MAXIMUM HEAD ON TOP OF LAYER 11	0.012	
LOCATION OF MAXIMUM HEAD IN LAYER 10 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 14	0.00000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 15	0.000000	0.00009
AVERAGE HEAD ON TOP OF LAYER 15	0.000	
MAXIMUM HEAD ON TOP OF LAYER 15	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 14 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	2.22	23399.3594

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3865
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1160

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	6.2002	0.2583
2	0.0125	0.0501
3	0.0000	0.0000
4	0.1875	0.7500
5	0.2700	0.0450
6	38.9760	0.2320
7	0.8100	0.0450
8	0.0000	0.0000
9	2.7840	0.2320
10	0.0025	0.0100
11	0.0000	0.0000
12	0.1875	0.7500
13	1.3920	0.2320
14	1.1520	0.0320
15	5.5560	0.4630
SNOW WATER	0.000	

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APPENDIX D

COVER SYSTEM COMPONENT DESIGN

Waste Consolidation

URS Greiner Woodward Clyde

Job Solutia Sauget | Project No. C10000 3899.00 | Sheet 1 of 2

Description Waste Consolidation | Computed by M. Brungard | Date 5/12/00

Checked by Bill Weber | Date 5/25/00

Reference

Purpose: Estimate Cover settlement due to waste consolidation

Configuration: Max. Waste thickness = 16'
Cover Soil thickness = 2'

Assumptions: Waste material is a sandy silt soil
Liquid Limit is less than 40
Material will be dried to meet paint filter reqmts
Material will be compacted to some degree in place

Calculations: Since actual consolidation parameters for waste are unavailable, use correlations to estimate parameters

For remolded clays: $C_c = 0.007(LL - 7)$

$= 0.007(40-7)$

$= \underline{0.23}$

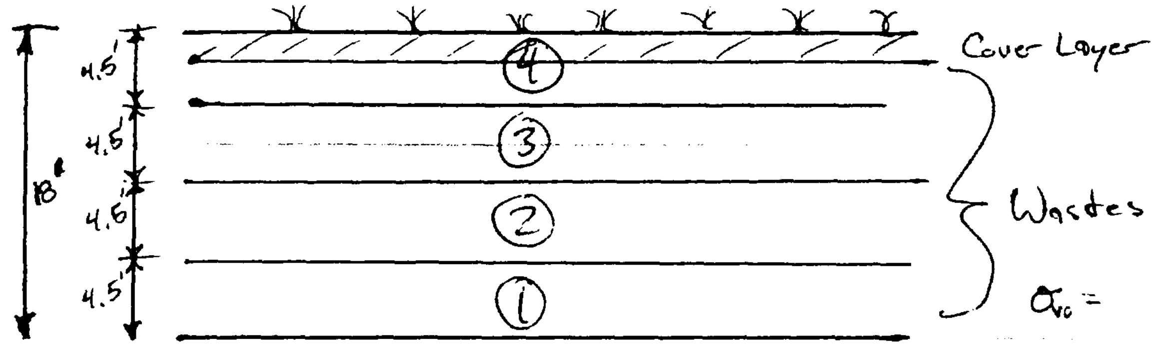
Since wastes will be compacted, using the C_c for normally consolidated soil above is not appropriate. Use C_r.

C_r is reportedly about 5 to 10% of C_c, source: An Introduction to Geotechnical Engineering, Holtz & Kovacs, Prentiss Hall, 1981, pg 341.

Use $C_r = 0.023$ in calculations

Void Ratio is unknown, but using 0.6 as the void ratio should produce conservative settlement results.

Use $e_o = 0.6$



Use γ = 115 pcf for wastes & cover

$$\text{settlement} = C_r \frac{H}{1+e_0} \log \frac{\sigma'_{vc}+\Delta\sigma_v}{\sigma'_{vc}}$$

use $\sigma'_{vo} = 2.25' \times 115\text{pcf} = 260\text{psf}$ at middle of each layer

Layer 1; $\Delta\sigma_v = (3\times 4.5') \times 115\text{pcf} = 1552$ psf

1 settlement $= 0.023 \frac{4.5'}{1+0.6} \log \frac{260+1552}{260} = 0.05' = \underline{\underline{0.6''}}$

Layer 2; $\Delta\sigma_v = (2\times 4.5') \times 115\text{pcf} = 1035$ psf

2 settlement $= 0.023 \frac{4.5}{1+0.6} \log \frac{260+1035}{260} = 0.045' = \underline{\underline{0.5''}}$

Layer 3; $\Delta\sigma_v' = 4.5' \times 115$ pcf $= 520$ psf

3 settlement $= 0.023 \frac{4.5'}{1+0.6} \log \frac{260+520}{260} = 0.03' = \underline{\underline{0.4''}}$

Layer 4 $\Delta\sigma_v = 2' \times 115$ pcf $= 230$ psf

4 settlement $= 0.023 \frac{2.5}{1+0.6} \log \frac{260+230}{260} = 0.01' = \underline{\underline{0.1''}}$

Total Settlement at Cover Surface $\approx \underline{\underline{1.6''}}$

Conclusion: The total settlement above is overstated since a portion of the settlement should occur during waste placement, reducing the actual settlement of the completed cover system.

The actual cover system settlement is estimated @ 1"

Run-off Velocity/Sheet Flow

URS Greiner Woodward Clyde

Job: Solutia Sauget	Project No. C10000 5899.00	Page ___ of ___	Sheet 1 of 1
Description: Runoff Velocity Sheet Flow	Computed by M. Brungard	Date 5/10/00	
	Checked by Bill Weber	Date 5/25/2000	
		Reference	

Purpose: Estimate runoff velocity on cover system under sheet flow conditions.

Method: Use a Time of Travel (T_T) equation to estimate velocity.

Use
Flow Length = 300' = (L)
slope = 3% to 12% = (S)
Manning Sheet Flow (n) = 0.15 – for short grass
2 yr - 24 hr Rainfall = 3.28 in from Huff & Angel, 1989 (P)

$$T_T = \frac{0.007 (nL)^{0.8}}{(P)^{0.5}\, S^{0.4}}$$

Solution:

(3%) $T_T = \frac{0.007(0.15(300'))^{0.8}}{\sqrt{3.28} \times 0.03^{0.4}} = .33 \text{ hr} = 1189 \text{ sec}$ ✓

(12%) $T_T = \frac{0.007(0.15(300'))^{0.8}}{\sqrt{3.28} \times 0.12^{0.4}} = .19 \text{ hr} = 683 \text{ sec}$ ✓

(3%) Velocity $= \frac{300'}{1189 \text{ sec}} =$ 0.25 ft/sec

(12%) Velocity $= \frac{300'}{683 \text{ sec}} =$ 0.44 ft/sec

Suitability of Grassed Surfaces for Erosion Control.

Based on the maximum allowable velocities for grassed channel linings on easily erodible soils, the max. velocity is about 3 ft/sec, from Table 10-5, Municipal Stormwater Management, Debo & Reese, Lewis Publishers, 1995.

* Therefore, grassed surfaces are permissible for the cover.
3 ft/sec >> 0.44 ft/sec

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Quick TR-55 Ver.5.47   S/N:
Executed: 16:27:44   05-08-2000    s:\1999\00026\SAUGET1.TCT

                    Solutia Sauget Waste Area Peak Flow          MB


                    Tc COMPUTATIONS FOR: waste

 SHEET FLOW (Applicable to Tc only)
     Segment ID
     Surface description                          graded waste
     Manning's roughness coeff., n                      0.0110
     Flow length, L (total < or = 300)      ft          300.0
     Two-yr 24-hr rainfall, P2              in          3.280
     Land slope, s                        ft/ft        0.0200
                         0.8
          .007 * (n*L)
     T =  --------------                    hrs          0.05          =  0.05
              0.5     0.4
           P2    *   s

 SHALLOW CONCENTRATED FLOW
     Segment ID
     Surface (paved or unpaved)?
     Flow length, L                         ft            0.0
     Watercourse slope, s                 ft/ft        0.0000

                             0.5
     Avg.V =  Csf *  (s)                   ft/s        0.0000
     where:   Unpaved Csf = 16.1345
              Paved   Csf = 20.3282

     T = L / (3600*V)                       hrs          0.00          =  0.00


 CHANNEL FLOW
     Segment ID
     Cross Sectional Flow Area, a         sq.ft          0.00
     Wetted perimeter, Pw                    ft          0.00
     Hydraulic radius, r = a/Pw              ft         0.000
     Channel slope, s                     ft/ft        0.0000
     Manning's roughness coeff., n                     0.0000

                      2/3    1/2
          1.49  *  r    *  s
     V =  --------------------             ft/s        0.0000
                   n

     Flow length, L                          ft             0

     T = L / (3600*V)                       hrs          0.00          =  0.00

        ::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
                                                 TOTAL TIME (hrs)        0.05
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Quick TR-55 Version: 5.47 S/N:

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Solutia Sauget Waste Area Peak Flow

MB

CALCULATED
DISK FILE: s:\1999\00026\SAUGET1 .GPD

Drainage Area	(acres)	3	--->	0.0047 sq.mi.
Runoff Curve Number	(CN)	90		
Time of Concentration, Tc	(hrs)	.05		
Rainfall Distribution	(Type)	II		
Pond and Swamp Areas	(%)	0	--->	0.0 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	25		
Rainfall, P, 24-hr (in)	6.02		
Initial Abstraction, Ia (in)	0.222	0.222	0.222
Ia/p Ratio	0.037	0.000	0.000
Unit Discharge, * qu (csm/in)	1191	0	0
Runoff, Q (in)	4.87	0.00	0.00
Pond & Swamp Adjustment Factor	1.00	1.00	1.00
PEAK DISCHARGE, qp (cfs)	27	0	0

Summary of Computations for qu

Ia/p	#1	0.100	0.000	0.000
C0	#1	2.553	0.000	0.000
C1	#1	-0.615	0.000	0.000
C2	#1	-0.164	0.000	0.000
qu (csm)	#1	1190.884	0.000	0.000
Ia/p	#2	0.100	0.000	0.000
C0	#2	2.553	0.000	0.000
C1	#2	-0.615	0.000	0.000
C2	#2	-0.164	0.000	0.000
qu (csm)	#2	1190.884	0.000	0.000
* qu (csm)		1191	0	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$
$$qp\ (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond\ \&\ Swamp\ Adj.)$$

Cover System Stormwater Control

URS

7650 West Courtney Campbell Causeway
Tampa, FL 33607-1462
Tel: 813.286.1711

Problem

1- Design a dropstructure to convey stormwater runoff from the top of the landfill to a perimeter ditch Located at the North side of the landfill Cell

Given

Landfill drainage Area = 5 Ac.

Ditch lining : Grass

C = 0.8

Solution

- Use Concrete structure w/Grate inlet fitted with 24"RCP
- Use Grassed ditch to Convey the flow with the following Cross Section:

Left side slope = 3:1

Right side slope = 4:1 (adjacent to landfill slope)

Bottom width = 2'

depth = 1.5

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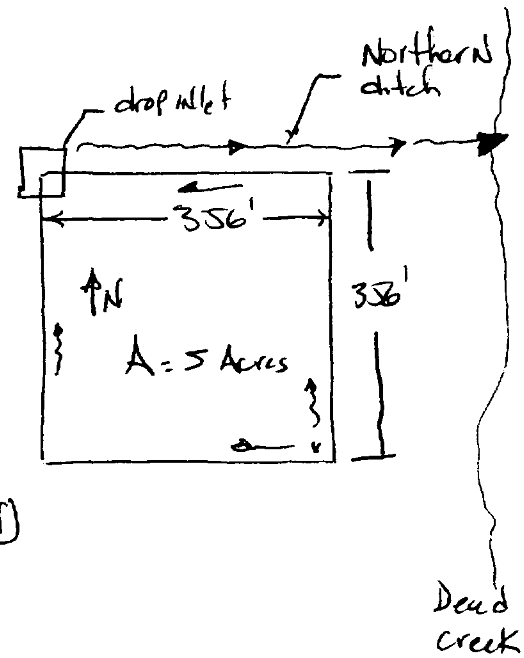
Tampa, FL 33607-1462
Tel: 813.286.1711

JOB Sauget SHEET 2 OF 3 PROJ. NO.
DESCRIPTION Landfill Drainage system COMPUTED BY DCPE DATE 5/1/01
CHECKED BY WJW DATE 5/1/01

Calculations

Use rational method to Calculate Q_{max}



$Q = CIA$

$C = 0.8$; $A = 5$ Ac.

$T_c = \frac{356 \times 2}{60V}$

$V = 1.6$ ft/sec (from Fig 2-1 of TESS manual)

$\therefore T_c \simeq 12$ min.

$I_{25,24} = 7.96$ (Fig 4-20ad)

$\therefore Q = 0.8 \times 7.96 \times 5 = 32$ ft^3/sec.

Size Drop inlet Pipe

$V^2 = 2gh$ (assuming Inlet Control)

$\frac{Q^2}{A^2} = 2gh$

$Q^2 = 2ghA^2$

Check head build up for 24-inch pipe

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Tampa, FL 33607-1462
Tel: 813.286.1711

JOB Sauget SHEET 3 OF 3 PROJ. NO.
DESCRIPTION landfill Drainage system COMPUTED BY DATE 5/1/01
CHECKED BY WJW DATE 5/1/01

$(32)^2 = 2 \times 32.2 \times h \times (2.76)^2$

$\therefore h \approx 2.0$ ft

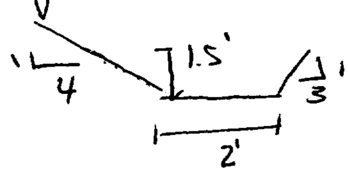
total inside inlet depth = 24" (pipe) + 2' (head) = 4 ft

size ditch @ North end to carry $Q_{max} = 32$ ft³/s.

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Assume ditch depth = 1.5 ft & bottom width = 2'

$A = (2 \times 1.5) + 3 (1.5)^2 \times 0.5$
$+ 4 (1.5)^2 \times 0.5$
$= 10.83$ ft²



$P = 12.93$

$R = \frac{10.83}{12.93} = 0.84$

$Q = \frac{1.486}{.02} \times 10.83 \times 0.84^{2/3} \times .005^{1/2} \approx 51$ ft³/sec.

Since $Q_{calculated} > Q_{flow}$. ditch section ok.

Outlet Channel Design

URS

Job: Solutia - Sweet
Project No. C100004051.01
Description: Capacity Check for North Ditch - Downschute
Computed by: WJW
Date: 5/1/2001
Checked by: DQ
Date: 5/11/01

Reference

PROBLEM: Will ditch handle required flow?

GIVEN: Ditch dimensions from design drawings

Required flow $Q = 51\ ft^3/s$ (from previous calcs)

REFERENCES:

Bedient, Philip B., and Wayne C. Huber, 1992, Hydrology and Floodplain Analysis, 2nd Ed., Addison-Wesley Publishing Co., New York.

Chow, Ven Te, Ph.D., 1959, Open Channel Hydraulics, McGraw-Hill Book Company, New York

"Manual for Erosion and Sediment Control in Georgia," 1990, Georgia Soil and Water Conservation Commision.

ASSUMPTIONS: Stated in calcs

CONCLUSION: The calculations show the given channel flowing 20.7 in deep at a velocity of 3.6 ft/s.

The channel is 24 in deep which is sufficient to contain the water

Given a grass lined channel with a bottom slope of 0.4%, the references require the velocity to be less than 5 ft/s. The design velocity is 3.6 ft/s which meets this criteria.

∴ The ditch is sufficient as designed.

URS

Job: Solutia Sauget | Project No. C10000 4051.01 | Sheet ___ of ___

Description: Capacity Check for North Ditch - Downchute | Computed by: WJW | Date: 5/1/2001

Checked by: DPE | Date: 5/1/01

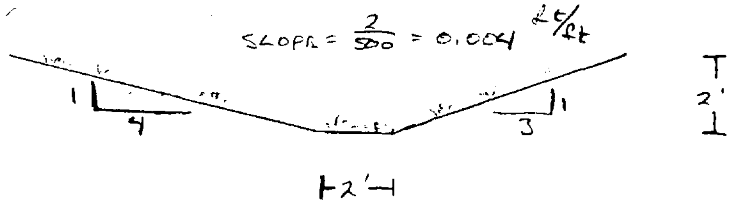
Reference

Solution:

Calc. Depth

Required flow rate $Q = 51\ ft^3/s$

Channel Demensions



Manning's $n = 0.025$ (Bedient, 1992)

Using AutoCAD to solve for Mannings Equation

$$V = \frac{1.49}{n} R^{2/3} \sqrt{S}$$

@ $Q = 51\ ft^3/s$ Depth = 20.8 in

∴ The 24 in deep channel will contain the flow

Consider Velocity

At $Q = 51\ ft^3/s$ the flow velocity is 3.6 ft/s

From Chow Table 7-6 and the Georgia Development Manual Table 6-31, most grasses grown in easily eroded soils with a slope less than 5% should have a water velocity less than 5 ft/s

∴ Given the bottom slope of 0.4% and the water velocity of 3.6 ft/s the designed channel is sufficient

PAGE 3 of 6

TABLE 7.1

Values of Roughness Coefficient *n* in Manning's formula

NATURE OF SURFACE	*n* MIN	*n* MAX
Closed Conduits		
Neat cement surface	0.010	0.013
Wood-stave pipe	0.010	0.013
Plank flumes, planed	0.010	0.014
Vitrified sewer pipe	0.010	0.017
Metal flumes, smooth	0.011	0.015
Concrete, precast	0.011	0.013
Cement mortar surfaces	0.011	0.015
Plank flumes, unplaned	0.011	0.015
Common clay drainage tile	0.011	0.017
Concrete, monolithic	0.012	0.016
Brick with cement mortar	0.012	0.017
Cast iron	0.013	0.017
Cement rubble surfaces	0.017	0.030
Riveted steel	0.017	0.020
Canals and ditches, smooth earth	0.017	0.025
Metal flumes, corrugated	0.022	0.030
Canals		
Dredged in earth, smooth	0.025	0.033
In rock cuts, smooth	0.025	0.035
Rough beds and weeds on sides	0.025	0.040
Rock cuts, jagged and irregular	0.035	0.045
Natural Streams		
Smooth and straight	0.025	0.033
Rough weeds and stones	0.045	0.060
Very weedy, deep pools	0.075	0.150
Floodplains		
Pasture	0.025	0.05
Brush	0.035	0.16
Trees		
Dense willows	0.11	0.20
Cleared with stumps	0.03	0.05
Heavy timber	0.08	0.12

RETARDANCE*

of r	ance
	Very high
	High
	Moderate
	Low
	Very low
	High
	Moderate
	Low
	Low
	Very low

ble velocity of flow in a
t severe erosion in the
ible velocities for differ-
itions, recommended on
n Service, are shown in

ss for the channel lining
the plant will grow and
e hydraulic viewpoint,
sidered. In general, a
ining. On steep slopes,
zu, will develop channel-
fc ing. For slopes
ted sod-forming grasses,
and smooth brome, are
occurs. Because of the
asses, the top portion of
asses that do not spread
ablishment of the lining,
ommended. Sometimes
il permanent covers by
in channels may be con-
develop channeled flow,

f grass for channel lining
mined from the condition
. During the period of

Page 4 of 6

establishment, the grass will grow and the channel will be stabilized under a condition of low degree of retardance. The channel will not reach its maximum capacity until the grass cover is fully developed and well established. Therefore, it is suggested that the hydraulic design of a grassed channel consist of two stages. The first stage (A) is to design the channel for stability, that is, to determine the channel dimensions under the condition of a *lower* degree of retardance. The second stage

TABLE 7-6. PERMISSIBLE VELOCITIES FOR CHANNELS LINED WITH GRASS*

Cover	Slope range, %	Permissible velocity, fps	
		Erosion-resistant soils	Easily eroded soils
Bermuda grass	0–5	8	6
	5–10	7	5
	>10	6	4
Buffalo grass, Kentucky bluegrass, smooth brome, blue grama	0–5	7	5
	5–10	6	4
	>10	5	3
Grass mixture	0–5	5	4
	5–10	4	3
	Do not use on slopes steeper than 10%		
Lespedeza sericea, weeping love grass, ischaemum (yellow bluestem), kudzu, alfalfa, crabgrass	0–5	3.5	2.5
	Do not use on slopes steeper than 5%, except for side slopes in a combination channel		
Annuals—used on mild slopes or as temporary protection until permanent covers are established, common lespedeza, Sudan grass	0–5	3.5	2.5
	Use on slopes steeper than 5% is not recommended		

REMARKS. The values apply to average, uniform stands of each type of cover. Use velocities exceeding 5 fps only where good covers and proper maintenance can be obtained.

* U.S. Soil Conservation Service [41].

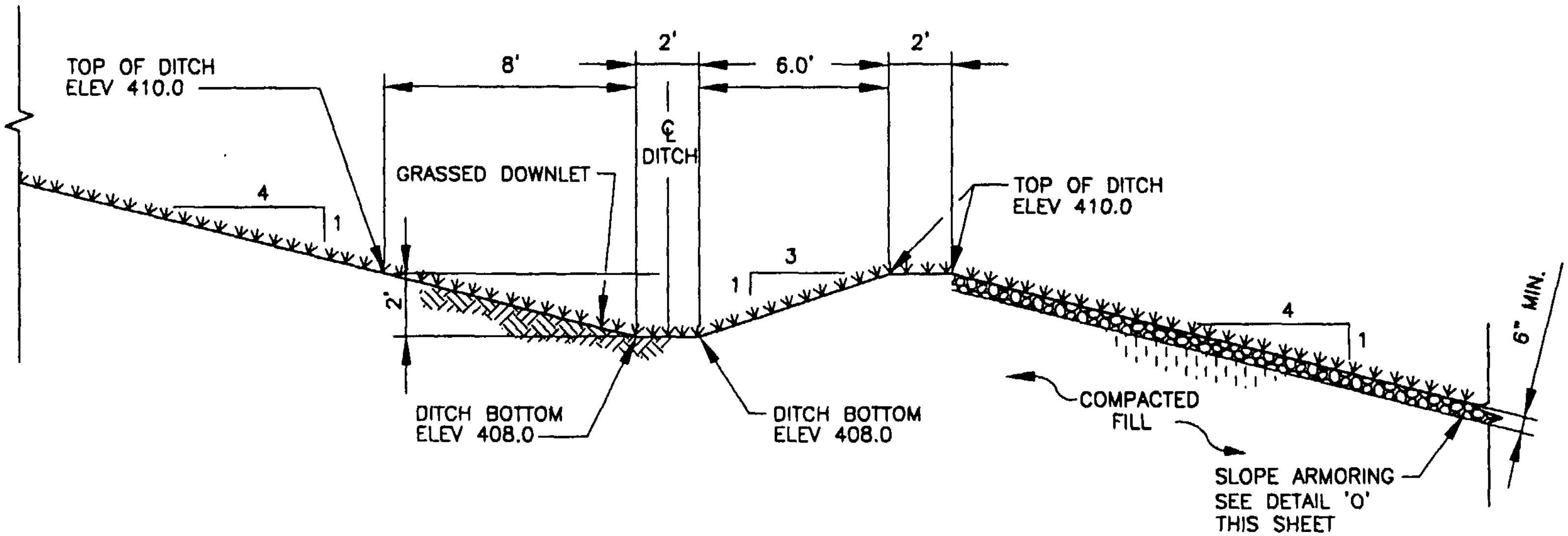
(B) is to review the design for maximum capacity, that is, to determine the increase in depth of flow necessary to maintain a maximum capacity under the condition of a *higher* degree of retardance. For instance, if common lespedeza is selected as the grass for lining, the common lespedeza of low vegetal retardance (green, average length 4.5 in.) is used for the first stage in design. Then, in the second stage, the common lespedeza of moderate vegetal retardance (green, uncut, average length 11 in.) should be used. Finally, a proper freeboard is added to the computed

TABLE 6-31

PERMISSIBLE DESIGN VELOCITIES

Cover	PERMISSIBLE VELOCITY[1]		
	Slope range (percent)	Erosion Resistant Soils[5] (ft./sec.)	Easily Eroded Soils[6] (ft./sec.)
Bermuda	0-5 5-10 over 10	6 5 4	5 4 3
Tall Fescue Bahia	0-5 5-10 over 10	5 4 3	5 4 3
Grass-legume mixtures	0-5 5-10[2]	5 4	4 3
Sericea lespedeza Annuals[4] - Small grains (rye, millet) Rye grass	0-5[3]	3.5	2.5
Stone center	All	(as determined by stone size from Rp section)	

1 Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.
2 Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
3 Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
4 Annuals - use on mild slopes or as temporary protection until permanent covers are established.
5 Erosion resistant soils include those with a higher clay content and high plasticity. Typical soil textures are silty clay, sandy clay, and clay.
6 Easily erodible soils include those with a high content of fine sand or lower plasticity. Typical soil textures are fine sand, silt, sandy loam, and silty loam.



NOTE:

SLOPE ARMORING TO BEGIN AT ELEV 410.0 ALONG DOWNSHUTE.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	DRAWING TITLE **DOWNCHUTE SECTION**	FIGURE 5-6

PAGE 6 of 6

Manning's Equation Output
From ACAD Land Development

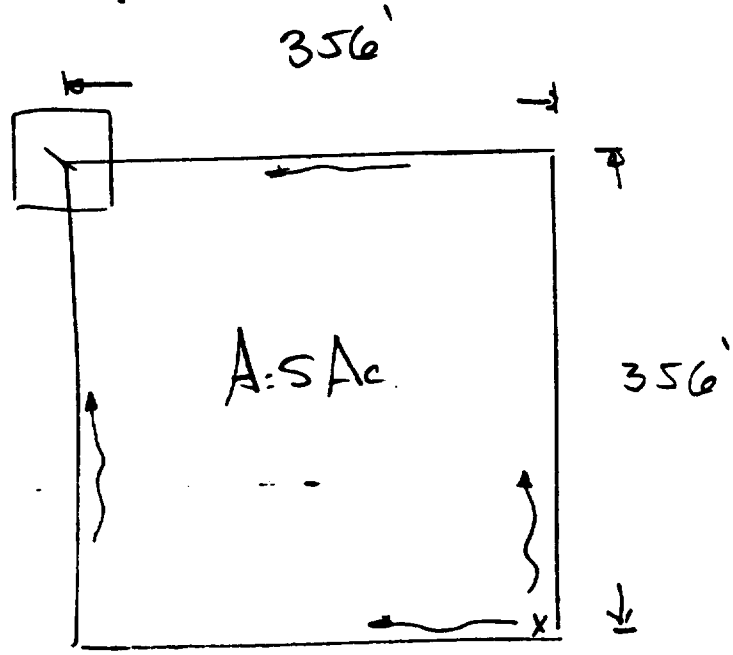
Channel Calculator

	Given Input Data:	
Shape	Trapezoidal	
Solve for	Depth of Flow	
Flowrate	51.0000	cfs
Slope	0.0040	ft/ft
Manning's n	0.0250	
Height	24.0000	in
Bottom Width	24.0000	in
Left Slope	0.2500	ft/ft (V/H)
Right Slope	0.3333	ft/ft (V/H)
	Computed Results:	
Depth of Flow	20.7989	in
Velocity	3.6477	fps
Full Flowrate	71.5070	cfs
Area	18.0006	ft2
Perimeter	198.8560	in
Flow Area	13.9813	ft2
Flow Perimeter	175.5336	in
Hydraulic Radius	11.4697	in
Top Width	169.5982	in
Flow Condition	Subcritical	

Cover System Stormwater Control

URS
7650 West Courtney Campbell Causeway
Tampa, FL 33607-1462
Tel: 813.286.1711

JOB DESCRIPTION Singet
SHEET 1 OF 5 PROJ. NO.
COMPUTED BY D ELHAJJ DATE 2/21/01
CHECKED BY WJW DATE 2/26/01



Use Rational method to Calculate Qmax

$Q = C I A$

$A = 5$ Ac ; $C = 0.8$

$T_c = \dfrac{356 \times 2}{60\,V}$

$V = 1.6$ ft/s (from Fig 3-1 of TR 55 manual)

7.42

$\therefore T_c \approx 12$ min

$I_{25,24hr} = 7.96$ (from fig [illegible])

URS
7650 West Courtney Campbell Causeway
Tampa, FL 33607-1462
Tel: 813.286.1711

JOB Summit
DESCRIPTION
SHEET 2 OF 5 PROJ. NO.
COMPUTED BY DOE DATE 2/21/01
CHECKED BY WJW DATE 2/26/01

$$\therefore Q_{25,24} = CIA = 0.8 \times 7.95 \times 5 = 32 \ ft^3/s$$
$\times A$

Size pipe for drop inlets

$$V^2 = 2gh$$

$$\frac{Q^2}{A^2} = 2gh$$

$$(32)^2 = 2ghA^2$$

determine head build up for 24"

$A = 2.76$ for 24" HDPE
$\times (2.76)^2 \times h$

$h \approx 2.0$ ft

Inlet

$+ 2.0$

$= 4.00 ft$

URS

7650 West Courtney Campbell Causeway
Tampa, FL 33607-1462
Tel: 813.286.1711

JOB: Sauget
DESCRIPTION:

 PROJ. NO. [illegible]
COMPUTED BY: DQE DATE:
CHECKED BY: WTW DATE: 2/26/2001

drop ditch depth to 1.5 ft

Calculate Q:

$A = (2 \times 1.5) + 3 \times (1.5)^2 \times 0.5 + 4 \times (1.5)^2 \times 0.5$

$= 10.83$

$P = 2 + \sqrt{22.50} + \sqrt{3[illegible]}$

$= 12.93$

$R = \frac{10.88}{12.93} = 0.84$

$Q = \frac{1.486}{.03} (10.88) (0.84)^{2/3} (.005)^{1/2}$

$\approx 51\ ft^3/s$

∴ 2' bottom width 1.5' [illegible]

[illegible] 51

[illegible] provide the capacity

[illegible] in [illegible] to [illegible]

URS

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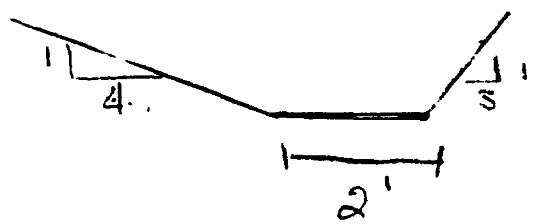
Tampa, FL 33607-1462
Tel: 813.286.1711

JOB Siegel SHEET 3 OF 5 PROJ. NO.
DESCRIPTION COMPUTED BY DOE DATE [illegible]
CHECKED BY UJW DATE 2/26/2001

Size ditch @ North End.



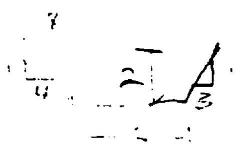
$Q = 32 \; ft^3/s$ slope $= 0.5\%$ $n = 0.020$

$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

Try channel depth of 2', with [illegible]

$A = $ (bottom + [illegible]) $= [illegible] \times 2 \times \frac{1}{2} + 8 \times 2 \times \frac{1}{2}$

$= (2 \times 2) + [illegible] = 18 \; ft^2$



$P = \sqrt{36+4} + 2 + \sqrt{64+4} = 16.57$

$R = \frac{A}{P} = \frac{18}{16.57} = 1.086$

$Q = \frac{1.486}{[illegible]} \; 18 \; (1.086)^{2/3} \; ([illegible])^{1/2}$

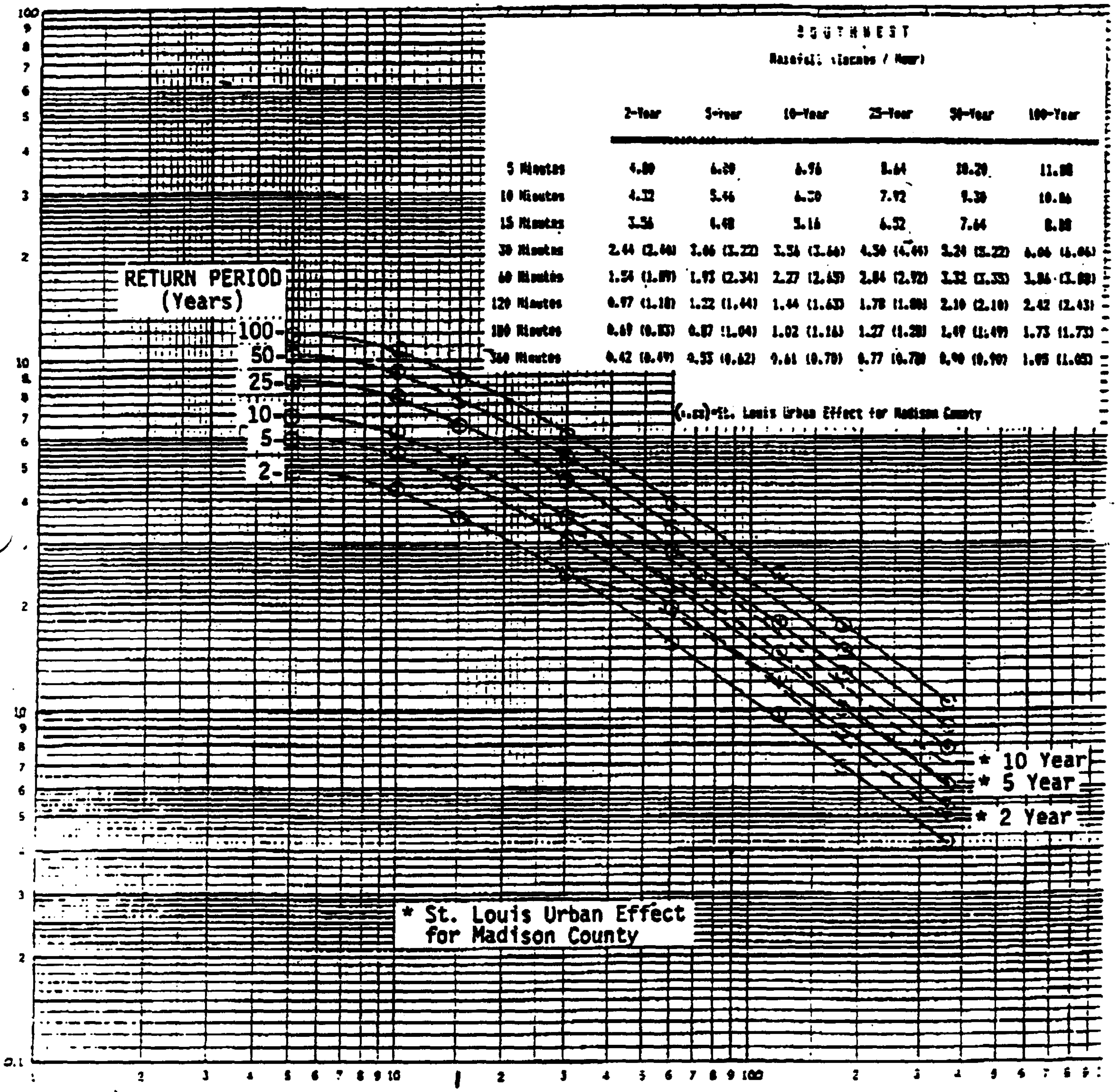
$= [illegible] \; ft^3/sec$

5/5

RAINFALL INTENSITY vs. DURATION

SOUTHWEST ILLINOIS

I.S.W.S. BULLETIN-70



SOUTHWEST

Rainfall (Inches / Hour)

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5 Minutes	4.80	6.30	6.96	8.64	10.20	11.88
10 Minutes	4.32	5.46	6.30	7.92	9.30	10.86
15 Minutes	3.56	4.48	5.16	6.52	7.64	8.88
30 Minutes	2.44 (2.40)	3.06 (3.22)	3.54 (3.66)	4.50 (4.44)	5.24 (5.22)	6.06 (6.06)
60 Minutes	1.54 (1.89)	1.93 (2.34)	2.27 (2.65)	2.84 (2.92)	3.32 (3.33)	3.86 (3.88)
120 Minutes	0.97 (1.18)	1.22 (1.44)	1.44 (1.63)	1.78 (1.88)	2.10 (2.10)	2.42 (2.43)
180 Minutes	0.69 (0.83)	0.87 (1.04)	1.02 (1.16)	1.27 (1.28)	1.49 (1.49)	1.73 (1.73)
360 Minutes	0.42 (0.49)	0.53 (0.62)	0.61 (0.70)	0.77 (0.78)	0.90 (0.90)	1.05 (1.05)

(x.xx)=St. Louis Urban Effect for Madison County

Figure 4-202d
Page 8

DURATION (Minutes)

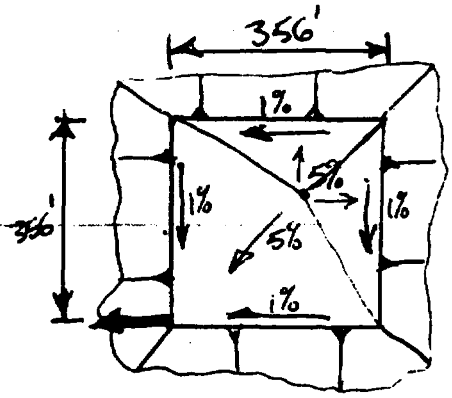
URS Greiner Woodward Clyde

Job	Solutia Sauget	Project No.	C10000 3899.00	Page ___ of ___	Sheet 1 of 5
Description	Cover System	Computed by	M. Brungard	Date	5/12/00
	Stormwater Control	Checked by	Bill Weber	Date	5/25/2000
				Reference	

Purpose: Estimate flow, velocity, & depth of flow for various portions of the cover system drainage.

Assumptions: The cover area is about 356' × 356' or 2.91 ac
The 100 yr, 24-hr storm is 8.21 inches, taken from: "Frequency Distributions & Hydroclimatic Characteristics of Heavy Rainstorms in Illinois" by Huff & Angel. The 2 yr, 24 hr storm is 3.28 inches.

Configuration:



Analysis: Use TR-55 methodology for Graphical Peak Flow.

Time of Concentration = 0.36 hr, output attached QTR-55

Peak Flow = 16 cfs, QTR-55 output attached

Perimeter Swale:

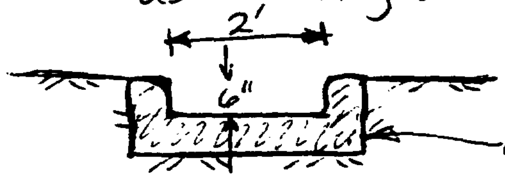
1% slope along swale

Flow Depth for 8 cfs is 0.58'
Flow Velocity for 8 cfs is 2.03 ft/sec

see attached Flow Master calculation sheets

For 8 cfs, the 1-foot swale depth is OK.
The flow velocity is OK for grassed protection.

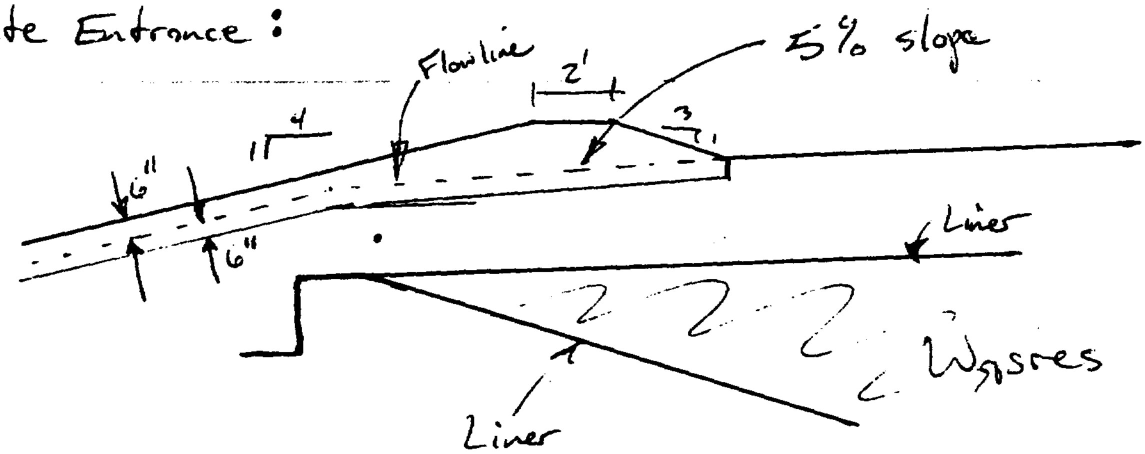
Downchute: Bring flow directly down the 4:1 side slope. Use rectangular section. 2' wide x 6" deep



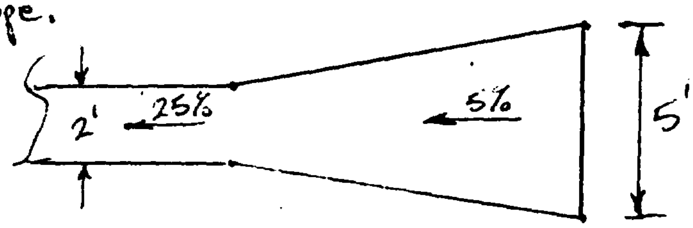
Depth of Flow = 0.38' = 4.5" < 6" Ok

see attached Flow Master sheet

Downchute Entrance:



The attached FlowMaster sheet shows that a 3' rectangular channel width keeps the depth of flow to about 6 inches for the 5% channel slope.



Make the entrance width transition from 5' down to 2' for the 5% slope channel section

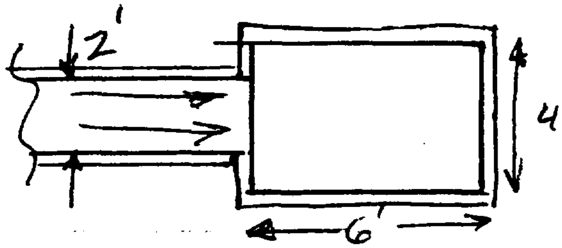
Stilling Basin: Since the Froude Number of the flow in the Downchute is fairly high (6), a rip rap apron is not suitable for this use.

Arbitrarily select a 1-foot sill height for the stilling basin. Use Figure 18.10 (attached) from the Hydraulic Design Handbook, Mays, McGraw-Hill, 1999 to determine hydraulic jump length. Use horizontal apron case.

$L/D = 6$, D is the sill height $= 1'$, so $\underline{L = 6'}$

Because the stilling basin will have an end sill, the hydraulic jump length is going to be shorter than 6'. Use $\underline{6'}$ for the stilling basin length anyhow.

Since the downchute channel is 2' wide, arbitrarily use a stilling basin width of $\underline{4'}$



Use an overflow sill length of $6' + 6' + 4' = \underline{16'}$

Estimate depth of flow over sill using broadcrested weir equation.

$$q = 0.55\left(\frac{2}{3}\right)\sqrt{2g}\,(d_3)^{1.5}$$

$$q = Q/L = 16\text{ cfs}/16' = \underline{1\ \tfrac{\text{cfs}}{\text{ft}}}$$

$$1 = 0.55(2/3)\sqrt{2(32.2)}\,(d_3)^{1.5}$$

$$1 = 2.94\,d_3^{1.5}$$

$$0.3398 = d_3^{1.5}$$

$$\underline{d_3 = 0.49'}$$

URS Greiner Woodward Clyde

Job Solutia Sauget	Project No. C100003899.00	Page ___ of ___	
Description Cover System Stormwater Control	Computed by M. Brunogard	Sheet 4 of 5	Date 5/12/00
	Checked by B. Webster	Date 5/23/2000	Reference

Overflow Velocity = $\cancel{2q}$ q/d_c at sill. For Broad-crested weirs, the d_c is roughly 2/3 the d_3 depth.

$$d_c = \tfrac{2}{3}(0.49') = \underline{0.33'}$$

$$q = 1\ \text{cfs/ft} \longleftarrow 16\ \text{cfs}/16\ \text{ft}$$

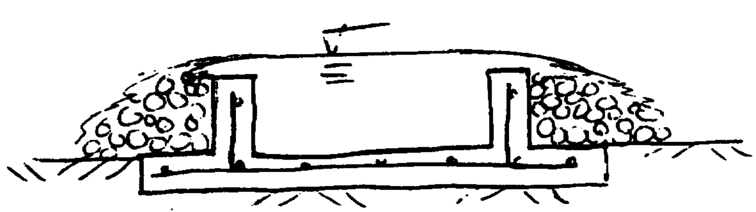
$$\text{velocity} = \frac{1\ \text{cfs/ft}}{0.33'} = 3\ \text{ft/sec}$$

check Froude Number:

$$F = \frac{V}{\sqrt{g d_c}} = \frac{3}{\sqrt{32.2(0.33)}} = 0.92$$

Flow over sill is subcritical, basin size is OK

Conclusion: 6' by 4' x 1' stilling basin will dissipate the energy from the downchute. Use a wide lip at the sill base to reduce erosion potential. Use a berm of gravel around the basin to further reduce erosion potential. Based on 3 ft/sec velocity, the average size of gravel should be at least 2 inches (diameter). Install a pipe sleeve through sill wall to allow basin to drain between events.



Structural Considerations: No significant loadings to basin, use temp & shrinkage steel. To meet min cover requirements, the concrete thickness is 6". Gross Area/ft = 0.5 ft²/ft

Steel Area = 0.002(Gross Area) = .001 ft² = .144 in²/ft.

Use #4 bars @ 12" OC.

Source: Hydraulic Design Handbook, Mays, McGraw Hill, 1999 (5/5)

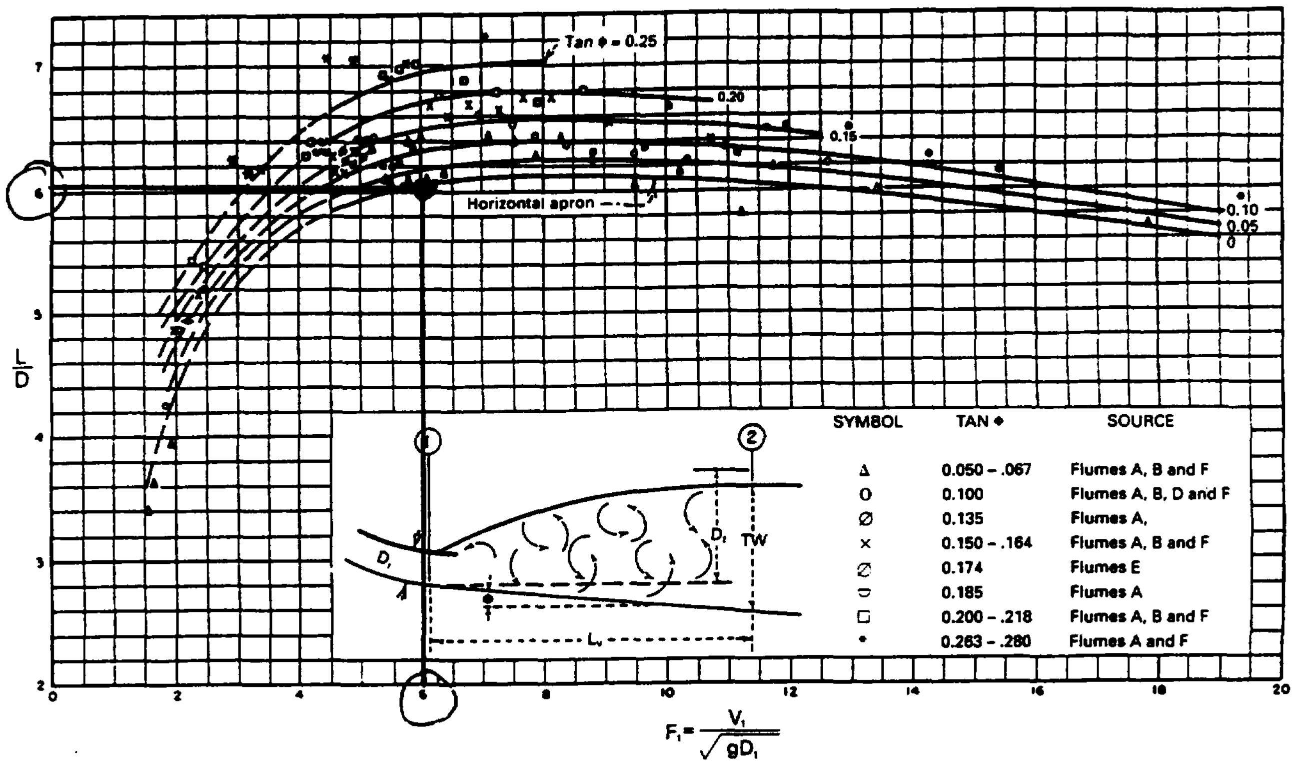


FIGURE 18.10 Jump length in terms of conjugate depth, D_2 for stilling basins with sloping aprons.(From Peterka, 1964)

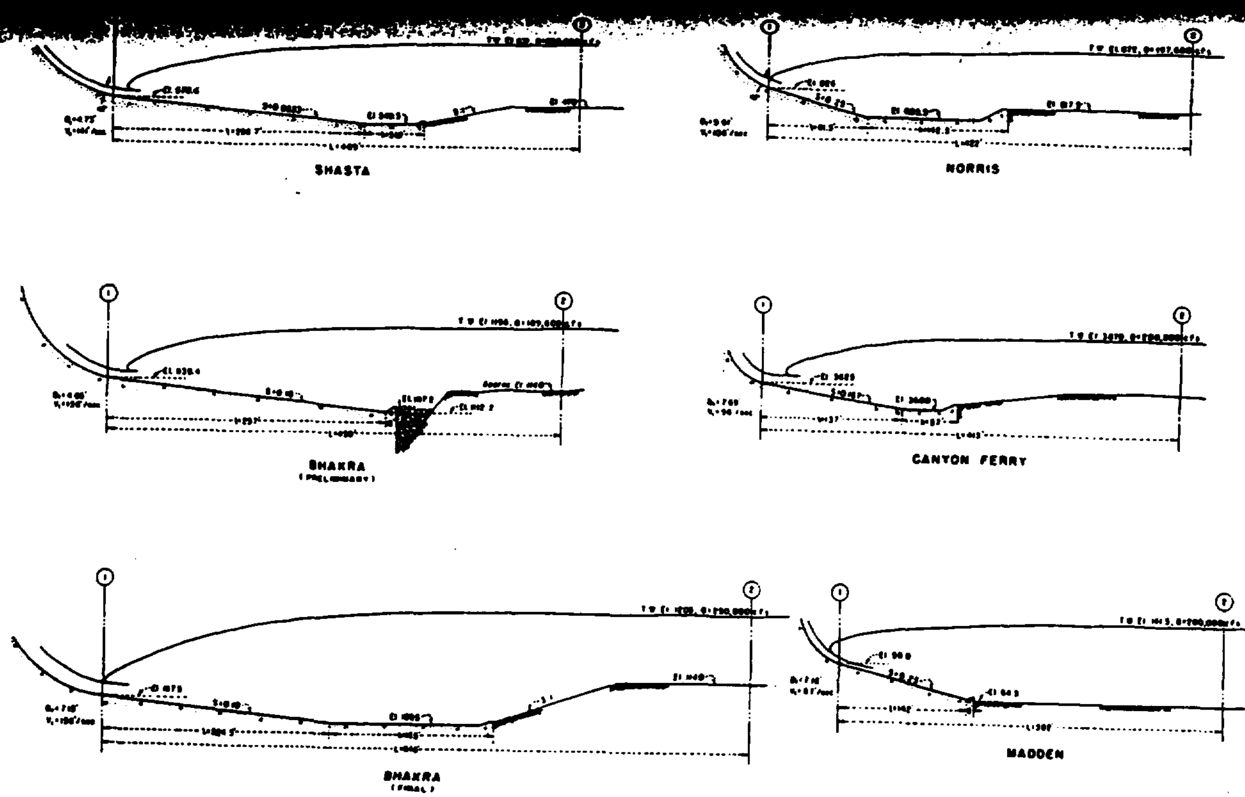


FIGURE 18.11(a) Existing stilling basins with sloping aprons.(From Peterka, 1964)

Quick TR-55 Ver.5.47 S/N:
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Solutia Sauget Containment Cell
Cover System Run Off

Tc COMPUTATIONS FOR: Grassed

SHEET FLOW (Applicable to Tc only)

Segment ID			
Surface description		Grassed	
Manning's roughness coeff., n		0.1500	
Flow length, L (total < or = 300)	ft	300.0	
Two-yr 24-hr rainfall, P2	in	3.280	
Land slope, s	ft/ft	0.0500	
$T = \frac{.007 * (n*L)^{0.8}}{P2^{0.5} * s^{0.4}}$	hrs	0.27	= 0.27

SHALLOW CONCENTRATED FLOW

Segment ID			
Surface (paved or unpaved)?			
Flow length, L	ft	0.0	
Watercourse slope, s	ft/ft	0.0000	
$Avg.V = Csf * (s)^{0.5}$	ft/s	0.0000	
where: Unpaved Csf = 16.1345			
Paved Csf = 20.3282			
T = L / (3600*V)	hrs	0.00	= 0.00

CHANNEL FLOW

Segment ID			
Cross Sectional Flow Area, a	sq.ft	3.93	
Wetted perimeter, Pw	ft	13.60	
Hydraulic radius, r = a/Pw	ft	0.289	
Channel slope, s	ft/ft	0.0100	
Manning's roughness coeff., n		0.0320	
$V = \frac{1.49 * r^{2/3} * s^{1/2}}{n}$	ft/s	2.0352	
Flow length, L	ft	700	
T = L / (3600*V)	hrs	0.10	= 0.10

::

TOTAL TIME (hrs) 0.36

Quick TR-55 Version: 5.47 S/N:

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Solutia Sauget Containment Cell
Cover System Run Off

CALCULATED
DISK FILE: s:\1999\00026\SAUGET2 .GPD

Drainage Area	(acres)	2.91	--->	0.0045 sq.mi.
Runoff Curve Number	(CN)	80		
Time of Concentration,Tc	(hrs)	.36		
Rainfall Distribution	(Type)	II		
Pond and Swamp Areas	(%)	0	--->	0.0 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	25	50	100
Rainfall, P, 24-hr (in)	6.02	7.07	8.21
Initial Abstraction, Ia (in)	0.500	0.500	0.500
Ia/p Ratio	0.083	0.071	0.061
Unit Discharge, * qu (csm/in)	622	622	622
Runoff, Q (in)	3.80	4.76	5.82
Pond & Swamp Adjustment Factor	1.00	1.00	1.00
PEAK DISCHARGE, qp (cfs)	11	13	16

Summary of Computations for qu

		Storm #1	Storm #2	Storm #3
Ia/p	#1	0.100	0.100	0.100
C0	#1	2.553	2.553	2.553
C1	#1	-0.615	-0.615	-0.615
C2	#1	-0.164	-0.164	-0.164
qu (csm)	#1	622.107	622.107	622.107
Ia/p	#2	0.100	0.100	0.100
C0	#2	2.553	2.553	2.553
C1	#2	-0.615	-0.615	-0.615
C2	#2	-0.164	-0.164	-0.164
qu (csm)	#2	622.107	622.107	622.107
* qu (csm)		622	622	622

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

$$qp\ (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond\ \&\ Swamp\ Adj.)$$

Downchute
Worksheet for Rectangular Channel

Project Description	
Project File	c:\haestad\fmw\sauget.fm2
Worksheet	Solutia Sauget Containment RectChute
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Slope

Input Data		
Mannings Coefficient	0.015	
Depth	0.38	ft
Bottom Width	2.00	ft
Discharge	16.00	cfs

Results		
Channel Slope	0.252115	ft/ft
Flow Area	0.76	ft²
Wetted Perimeter	2.76	ft
Top Width	2.00	ft
Critical Depth	1.26	ft
Critical Slope	0.008996	ft/ft
Velocity	21.05	ft/s
Velocity Head	6.89	ft
Specific Energy	7.27	ft
Froude Number	6.02	
Flow is supercritical.		

Downchute entrance
Worksheet for Rectangular Channel

Project Description	
Project File	c:\haestad\fmw\sauget.fm2
Worksheet	Solutia Sauget DnChute Entrance
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Slope

Input Data		
Mannings Coefficient	0.015	
Depth	0.52	ft
Bottom Width	3.00	ft
Discharge	16.00	cfs

Results		
Channel Slope	0.038123	ft/ft
Flow Area	1.56	ft^2
Wetted Perimeter	4.04	ft
Top Width	3.00	ft
Critical Depth	0.96	ft
Critical Slope	0.006428	ft/ft
Velocity	10.26	ft/s
Velocity Head	1.63	ft
Specific Energy	2.15	ft
Froude Number	2.51	
Flow is supercritical.		

Swale w/ 3:1 side and 5% side
Worksheet for Triangular Channel

Project Description	
Project File	c:\haestad\fmw\sauget.fm2
Worksheet	Solutia Sauget Containment Cell Swales
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.032	
Channel Slope	0.010000	ft/ft
Left Side Slope	3.000000	H : V
Right Side Slope	20.000000	H : V
Discharge	8.00	cfs

Results		
Depth	0.58	ft
Flow Area	3.93	ft^2
Wetted Perimeter	13.56	ft
Top Width	13.45	ft
Critical Depth	0.50	ft
Critical Slope	0.024004	ft/ft
Velocity	2.03	ft/s
Velocity Head	0.06	ft
Specific Energy	0.65	ft
Froude Number	0.66	
Flow is subcritical.		

Run-off Velocity/Sheet Flow

URS Greiner Woodward Clyde

Job: Solutia Sauget	Project No. C10000 5899.00	Page ___ of ___	Sheet 1 of 1
Description: Runoff Velocity Sheet Flow	Computed by M. Brungard	Date 5/10/00	
	Checked by Bill Weber	Date 5/23/2000	Reference

Purpose: Estimate runoff velocity on cover system under sheet flow conditions.

Method: Use a Time of Travel (T_T) equation to estimate velocity.

Use. Flow Length = 300' = (L)
slope = 3% to 12% = (S)
Manning Sheet Flow (n) = 0.15 - for short grass
2 yr - 24 hr Rainfall = 3.28 in from Huff & Angel, 1989 (P)

$$T_T = \frac{0.007 (nL)^{0.8}}{(P)^{0.5} \, S^{0.4}}$$

Solution: (3%) $T_T = \dfrac{0.007 (0.15(300'))^{0.8}}{\sqrt{3.28} \times 0.03^{0.4}} = .33 \text{ hr} = 1189 \text{ sec}$ ✓

(12%) $T_T = \dfrac{0.007 (0.15(300'))^{0.8}}{\sqrt{3.28} \times 0.12^{0.4}} = .19 \text{ hr} = 683 \text{ sec}$ ✓

(3%) Velocity $= \dfrac{300'}{1189 \text{ sec}} =$ <u>0.25 ft/sec</u>

(12%) Velocity $= \dfrac{300'}{683 \text{ sec}} =$ <u>0.44 ft/sec</u>

Suitability of Grassed Surfaces for Erosion Control.

Based on the maximum allowable velocities for grassed channel linings on easily erodible soils, the max. velocity is about <u>3 ft/sec</u>, from Table 10-5, Municipal Stormwater Management, Debo & Reese, Lewis Publishers 1995.

* Therefore, grassed surfaces are permissible for the cover.
<u>3 ft/sec >> 0.44 ft/sec</u>

Quick TR-55 Ver.5.47 S/N:
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Solutia Sauget Waste Area Peak Flow

MB

Tc COMPUTATIONS FOR: waste

```
SHEET FLOW (Applicable to Tc only)
    Segment ID
    Surface description                      graded waste
    Manning's roughness coeff., n                  0.0110
    Flow length, L (total < or = 300)     ft      300.0
    Two-yr 24-hr rainfall, P2             in      3.280
    Land slope, s                       ft/ft    0.0200
                          0.8
         .007 * (n*L)
    T =  --------------                hrs       0.05              =  0.05
            0.5    0.4
          P2    *   s

SHALLOW CONCENTRATED FLOW
    Segment ID
    Surface (paved or unpaved)?
    Flow length, L                        ft        0.0
    Watercourse slope, s                ft/ft    0.0000

                            0.5
    Avg.V =   Csf *   (s)               ft/s     0.0000
    where:    Unpaved Csf = 16.1345
              Paved   Csf = 20.3282

    T = L / (3600*V)                    hrs       0.00              =  0.00


CHANNEL FLOW
    Segment ID
    Cross Sectional Flow Area, a       sq.ft      0.00
    Wetted perimeter, Pw                  ft      0.00
    Hydraulic radius, r = a/Pw            ft     0.000
    Channel slope, s                    ft/ft    0.0000
    Manning's roughness coeff., n                0.0000

                       2/3     1/2
         1.49   *   r    *   s
    V =  --------------------           ft/s     0.0000
                    n

    Flow length, L                        ft          0

    T = L / (3600*V)                    hrs       0.00              =  0.00

    :::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
                                             TOTAL TIME (hrs)          0.05
```

Quick TR-55 Version: 5.47 S/N:

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Solutia Sauget Waste Area Peak Flow

NIB

CALCULATED
DISK FILE: s:\1999\00026\SAUGET1 .GPD

Drainage Area	(acres)	3	--->	0.0047 sq.mi.
Runoff Curve Number	(CN)	90		
Time of Concentration,Tc	(hrs)	.05		
Rainfall Distribution	(Type)	II		
Pond and Swamp Areas	(%)	0	--->	0.0 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	25		
Rainfall, P, 24-hr (in)	6.02		
Initial Abstraction, Ia (in)	0.222	0.222	0.222
Ia/p Ratio	0.037	0.000	0.000
Unit Discharge, * qu (csm/in)	1191	0	0
Runoff, Q (in)	4.87	0.00	0.00
Pond & Swamp Adjustment Factor	1.00	1.00	1.00
PEAK DISCHARGE, qp (cfs)	27	0	0

Summary of Computations for qu

Ia/p	#1	0.100	0.000	0.000
C0	#1	2.553	0.000	0.000
C1	#1	-0.615	0.000	0.000
C2	#1	-0.164	0.000	0.000
qu (csm)	#1	1190.884	0.000	0.000
Ia/p	#2	0.100	0.000	0.000
C0	#2	2.553	0.000	0.000
C1	#2	-0.615	0.000	0.000
C2	#2	-0.164	0.000	0.000
qu (csm)	#2	1190.884	0.000	0.000
* qu (csm)		1191	0	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
  If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)

Waste Consolidation

URS Greiner Woodward Clyde

Page ____ of ____

Sheet 1 of 2

Job: Solutia Sauget

Description: Waste Consolidation

Project No. C10000 3899.00

Computed by: M. Brungard

Date: 5/12/00

Checked by: Bill Weber

Date: 5/25/00

Reference

Purpose: Estimate Cover settlement due to waste consolidation

Configuration:

Max. Waste thickness = 16'

Cover Soil thickness = 2'

Assumptions:

Waste material is a sandy silt soil

Liquid Limit is less than 40

Material will be dried to meet paint filter reqmts

Material will be compacted to some degree in place

Calculations: Since actual consolidation parameters for waste are unavailable, use correlations to estimate parameters

For remolded clays: $C_c = 0.007(LL-7)$

$= 0.007(40-7)$

$= \underline{0.23}$

Since wastes will be compacted, using the C_c for normally consolidated soil above is not appropriate. Use C_r.

C_r is reportedly about 5 to 10% of C_c, source: An Introduction to Geotechnical Engineering, Holtz & Kovacs, Prentiss Hall, 1981, pg 340

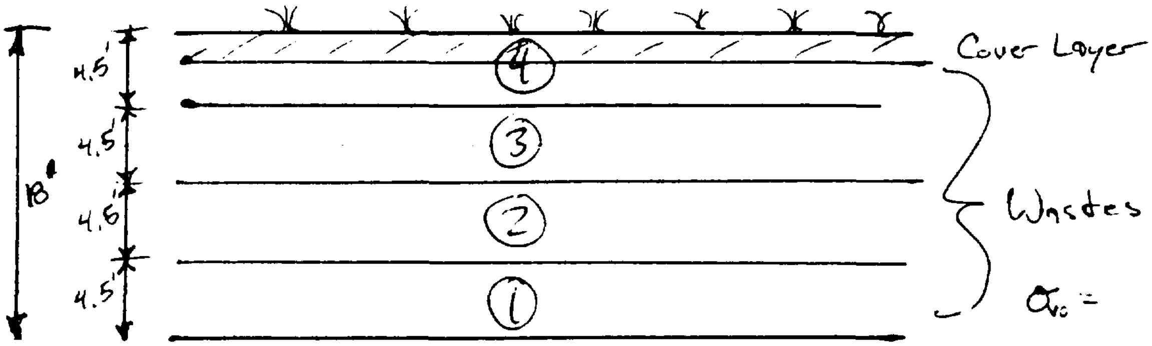
Use $C_r = 0.023$ in calculations

Void Ratio is unknown, but using 0.6 as the void ratio should produce conservative settlement results.

Use $e_o = 0.6$

URS Greiner Woodward Clyde

Job: Solutia Sauget	Project No. C10003899.00	Page ___ of ___	Sheet 2 of 2
Description: Waste Consolidation	Computed by M. Brungard	Date 5/12/00	
	Checked by Bill Weber	Date 5/25/2000	
		Reference	



Use $\gamma = 115$ pcf for wastes & cover

$$\text{settlement} = C_r \frac{H}{1+e_o} \log \frac{\sigma'_{vc} + \Delta\sigma_v}{\sigma'_{vc}}$$

use $\sigma'_{vo} = 2.25' \times 115\text{pcf} = 260\text{psf}$ at middle of each layer

Layer 1; $\Delta\sigma_v = (3 \times 4.5') \times 115\text{pcf} = 1552$ psf

1 settlement $= 0.023 \frac{4.5'}{1+0.6} \log \frac{260+1552}{260} = 0.05' = \underline{\underline{0.6}}$

Layer 2; $\Delta\sigma_v = (2 \times 4.5') \times 115\text{pcf} = 1035$ psf

2 settlement $= 0.023 \frac{4.5}{1+0.6} \log \frac{260+1035}{260} = 0.045' = \underline{\underline{0.5''}}$

Layer 3; $\Delta\sigma_v = 4.5' \times 115$ pcf $= 520$ psf

3 settlement $= 0.023 \frac{4.5'}{1+0.6} \log \frac{260+520}{260} = 0.03' = \underline{\underline{0.4''}}$

Layer 4 $\Delta\sigma_v = 2' \times 115$ pcf $= 230$ psf

4 settlement $= 0.023 \frac{2.5}{1+0.6} \log \frac{260+230}{260} = 0.01' = \underline{\underline{0.1''}}$

Total Settlement at Cover Surface $\approx \underline{\underline{1.6''}}$

Conclusion: The total settlement above is overstated since a portion of the settlement should occur during waste placement, reducing the actual settlement of the completed cover system.

The actual cover system settlement is estimated @ 1"

APPENDIX E

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS SAUGET AREA 1 TSCA LANDFILL CONSTRUCTION

Prepared for:

Solutia Inc.
575 Maryville Centre Drive
St. Louis, MO 63141

Prepared by:

URS

7650 West Courtney Campbell Causeway
Tampa, Florida 33607-1462
C100004051.00

April 2, 2001 Revision 1

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SECTION 01010

SUMMARY OF WORK

SECTION 01010

SUMMARY OF WORK

PART 1 GENERAL

1.0 SECTION INCLUDES

A. Background Information

B. General Requirements

C. Summary of Work

1.1 BACKGROUND INFORMATION

A. Solutia plans to construct a 500-foot (ft) by 500-ft TSCA landfill located in Cahokia, Illinois. This landfill will have a design capacity of 50,000 cubic yards. This landfill will contain non-native sediments and soils from in and adjacent to Dead Creek.

B. A containment cell will be constructed under this contract to contain non-native sediments and soils from in and adjacent to Dead Creek. The cell will consist of a double liner system and a cover system. The cover system consists of, from top to bottom, the following layers: vegetative cover, cover soil, geotextile, geonet, geomembrane, geosynthetic clay liners and tracked in-place fill. The double liner system will consists of, from top to bottom, the following layers: geotextile, sand drainage layer, primary geomembrane, tracked in-place soil, geotextile, geonet, secondary geomembrane, geosynthetic clay liner, capillary break ground layer, tracked in-place soil and subgrade.

1.2 GENERAL REQUIREMENTS

A. Authority of Construction Manager

1. The work will be reviewed, observed and inspected by the on-site Construction Manager in accordance with the contract, Plans, Specifications, the Construction Quality Assurance Manual for Installation of Geosynthetic Components and the Construction Quality Assurance Manual for Installation of Soil Components of the Lining and Final Cover Systems. The Construction Manager will decide all questions which may

arise as to the quality or acceptability of materials furnished and work performed; the manner of performance and rate of progress of the work; the interpretations of the Drawings and Specifications and the acceptable fulfillment of the contract on the part of the Contractor. Construction Manager's decisions will be final and binding.

B. Conformity with Drawings and Specifications

1. All work performed and all materials furnished shall be in conformity with the lines, grades, cross sections, dimensions, details, gradations, physical, and chemical characteristics of materials in accordance with tolerances shown on the Drawings required by the Specifications. Construction tolerances and accuracy limits will be as defined in the respective items of the contract or if not defined, as determined by the Construction Manager.

2. It is the responsibility of the Contractor to verify all quantities of materials shown on the Drawings before ordering same, as payment is provided for acceptable materials complete in place. The Contractor will not be paid for material rejected due to improper fabrication, excess quantity or for any other reasons within his control.

3. In the event the Construction Manager finds that the work performed or the materials used are not within conformity with the Drawings and Specifications, the affected material or product shall be removed and replaced or otherwise satisfactorily corrected by and at the expense of the Contractor.

4. Any deviations from the Plans, Specifications and approved Shop Drawings will be made only with the approval of the Construction Manager and with the concurrence of the Designer. All requests for variance or modification shall be by written communication from the Contractor to the Construction Manager.

5. The Specifications accompanying the Drawings are essential parts of the contract and a requirement occurring in one is as binding as though occurring in all. They are intended to be cooperative and to describe and provide for a complete work. In cases of disagreement, dimensions provided on figures shall govern over scaled dimensions, Drawings shall govern over Specifications, and addenda shall govern over both Specifications and Drawings.

C. Cooperation of Contractor

1. The Contractor shall designate, to the Construction Manager in writing, the name of a Superintendent, employed by the firm, regardless of how much of the work may be sublet. The Superintendent shall be cooperative, responsible and competent, English speaking, authorized to receive orders and to act for the Contractor. The Superintendent will be on-site and available at all times during construction of the perimeter containment levee, lining and final cover systems, and all appurtenant work. In the event a competent superintendent is not available, the Construction Manager may suspend work at no additional cost to the Owner until one is available.

D. Removal of Defective and Unauthorized Work

1. All work which has been rejected as being in nonconformance with the Drawings and Specifications shall be remedied or removed and replaced in an acceptable manner by the Contractor at his expense. Work done beyond the lines and grades given or as shown on the plans, or any extra work done without written authority will be considered as unauthorized and done at the expense of the Contractor and will not be paid for. Work so done may be ordered removed at the Contractor's expense. Upon failure on the part of the Contractor to comply with any order of the Construction Manager made under the provisions of this paragraph, the Construction Manager will have authority to cause defective work to be remedied or removed and replaced and unauthorized work to be removed and the cost thereof may be deducted from any moneys due or to become due to the contractor.

E. Protection of Adjoining Property

1. The Contractor shall take proper measures to protect the adjacent or adjoining property which might be injured by any process of construction, and, in case of any injury or damage resulting from any act or omission on the part of or on behalf of the Contractor, he shall restore at his own expense the damaged property to a condition similar or equal to that existing before such injury or damage was done, or he shall make good such injury or damage in an acceptable manner.

F. Contractor's Responsibility for Work

1. Until final written acceptance of the project by the Construction Manager, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or

from the nonexecution of the work. The Contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before final acceptance and shall bear the expense thereof which are a portion of the work, not damaged by the Contractor or his operations, except for damage to the work due to Acts of God (force majeure) such as earthquake, tidal wave, tornado, hurricane, or other cataclysmic phenomena of nature or acts of governmental authorities. In case of suspension of work for any cause, the Contractor shall be responsible for the preservation of all materials. He shall provide suitable drainage and shall erect temporary structures where required.

G. Work Near Electrical Power Lines

1. Any operations by the Contractor which are located near any electrical power lines shall be accomplished using established industry and utility safety practices. The Contractor shall consult with the appropriate utility company prior to beginning any such work. All associated costs will be the responsibility of the Contractor.

H. Workers and Equipment

1. The Contractor shall furnish such suitable machinery, equipment, and construction forces as may be necessary, in the opinion of the Construction Manager, for the proper prosecution of the work. Construction Manager may require the Contractor to provide additional resources to maintain the project schedule. Construction Manager may suspend the work until his requests are complied with.

2. All workers employed by the Contractor shall have such skill and experience as will enable them to properly perform the duties assigned. Any person employed by the Contractor or a subcontractor who, in the opinion of the Construction Manager, does not perform his work in a proper and skillful manner, or who is disrespectful, intemperate, disorderly or otherwise objectionable, shall at a written request of the Construction Manager be forthwith discharged and shall not be employed again on any of the work without written consent of the Construction Manager.

3. Contractor and all employees, subcontractors, supporting firms and incidental labor shall meet the minimum safety requirements for Solutia's Pensacola Plant.

SECTION 01050

CONSTRUCTION SURVEY

- Place gravel drains
- Install vegetated cover on cover system and slopes
- Grade berms to accommodate drainage
- Construct downlet structures

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION 01010

I. Final Clean Up

1. Upon completion of the work and before acceptance and final payment is made, the Contractor shall clean, remove rubbish and temporary structures from the site, restore in an acceptable manner all property which has been damaged during the prosecution of the work and leave the site of the work in a neat and presentable condition throughout.

J. Final Inspection

1. Whenever the work provided for in, and contemplated under, the contract has been satisfactorily completed (with the exception of any performance periods) and the final clean up performed, the Contractor shall notify in writing to the Construction Manager to make the "Final Inspection". Such inspection will be made as soon as possible, but not longer than (10) days after such notification. After such final inspection, if the work is found to be satisfactory (with the exception of any performance periods), the Contractor will be notified in writing of the acceptance of same. The "Final Acceptance" will not release the Contractor from responsibility for all items, materials, or equipment requiring performance test periods or final measurements unless otherwise shown in the contract.

1.3 SUMMARY OF WORK

A. General

1. The Contractor shall work closely and communicate regularly with the Owner in order to minimize conflicts and expedite the completion of the work. The Construction Manager serves as the Owner's representative.

2. All equipment and materials on-site during the work will be the responsibility of the Contractor. The Owner shall not be responsible for theft, vandalism or damage to any of the equipment or materials.

3. Contractor shall be required to prepare and adhere to a Quality Control Plan for field installation, as approved by the Construction Manager.

4. Contractor shall select and pay for an independent laboratory(ies) as required for testing soil and geosynthetic materials.

5. Contractor shall adhere to all health and safety requirements as identified in the Site Health and Safety Plan and as required by Plant and Solutia corporate safety requirements.

6. Contractor shall prepare and submit for approval by the Construction Manager all Work Plans, Safety Plans, and Construction Plans as required by these Specifications.

B. Work Covered by Contract Documents

1. Work of this Contract comprises the construction of a composite synthetic double lined disposal cell and final cover system designed in accordance with the requirements of the U.S. Environmental Protection Agency and the Illinois Environmental Protection Agency for Solutia Inc.

2. Principal Work Items to be performed by Contractor:

- Mobilization to site
- Site preparation to include clear and grub, borrow area development, erosion control, haul road development and stormwater management measures.
- Perimeter berm construction
- Construct capillary break ground layer and sump
- Install geotextile for separation
- Construct tracked in-place soil layer over geotextile fabric layer
- Install geosynthetic clay liner
- Secondary geomembrane installation
- Secondary leachate collection system installation including sumps and riser pipes
- Construct tracked in place soil layer on bottom
- Install primary geomembrane layer
- Construct primary leachate collection system drainage layer, sumps and riser pipes
- Install geotextile or primary collection system
- Place sand protective layer
- Place non-native sediments and selected soils adjacent to Dead Creek into cell (by others)
- Install cover system geosynthetics
- Construct perimeter toe drain
- Place cover and drainage layer soils

3.3 SURVEY REQUIREMENTS

A. Contractor shall reference survey and site reference points to permanent benchmarks and record locations of survey control points, with horizontal and vertical data, on Project Record Documents.

B. Contractor shall establish lines and levels, locate and lay out by instrumentation and similar appropriate means:

1. Site features to be constructed including necessary stakes for cut, fill, placement, and grading operations and stakes for slopes.

2. Grid along perimeter of cell work area to facilitate Contractor quality control activities.

C. Contractor shall verify layouts periodically during construction by same means.

3.4 SURVEYS FOR CONTRACTOR QUALITY CONTROL

A. Contractor shall perform surveys to determine as-built elevations of all cell components as required by the Specifications and the Contractor's Quality Control Plan and shall notify the Construction Manager prior to starting the work.

B. Contractor's field superintendent shall sign Surveyor's field notes or shall keep duplicate field notes and shall provide copies of same to the Construction Manager.

3.5 SURVEYS FOR MEASUREMENTS AND PAYMENT

A. Contractor shall perform surveys to determine percent of completed work including surveys to establish measurement reference lines. Contractor shall notify the Construction Manager prior to starting the survey.

B. Surveys shall be conducted after establishing a grid system sufficiently close between grid lines to determine the measured quantity. Grid spacings shall not be greater than 50 ft for determination of volume calculations, unless otherwise approved by the Construction Manager.

C. Contractor's field superintendent shall sign Surveyor's field notes and shall keep duplicate copy of field notes and shall calculate and certify quantities for progress payment purposes.

END OF SECTION 01050

SECTION 01050

CONSTRUCTION SURVEY

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Surveying Services

B. Surveys for Contractor Quality Control Program

C. Surveys for Measurements and Payment

D. Site Reference Points as Shown in the Plans

1.2 RELATED SECTIONS

A. Section 01010 - Summary of Work

1.3 DEFINITIONS

A. Land Surveyor: Surveyor shall be a registered land surveyor in the State of Illinois and acceptable to the Construction Manager.

B. Record Documents: All information collected by Surveyor.

1.4 SUBMITTALS

A. Contractor shall submit name, address, and telephone number of Surveyor to the Construction Manager before starting survey work.

B. On request of the Construction Manager, Contractor shall submit documentation verifying accuracy of survey work.

C. Contractor shall submit certificate signed by Surveyor certifying that elevations and locations of site constructed features are in conformance, or non-conformance, with Contract Documents.

1.5 PROJECT RECORD DOCUMENTS

A. Contractor shall maintain on site a complete, accurate log of control and survey work as it progresses.

B. Upon completion of the work or as requested by the Construction Manager, Contractor shall submit Record Documents to the Construction Manager.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 INSPECTION

A. Contractor shall verify locations of site reference and survey control points prior to starting work. Contractor shall promptly notify the Construction Manager of any discrepancies discovered.

3.2 SURVEY REFERENCE POINTS

A. Contractor shall utilize the information represented in the design drawings (Sheet C1.1) and documents to establish and install survey control and permanent reference points.

B. Contractor shall protect survey control points prior to starting sitework and preserve permanent reference points during construction. Contractor shall not relocate site reference points without prior written approval by the Construction Manager.

C. Contractor shall promptly report to the Construction Manager the loss, damage, or destruction of any reference point or relocation required because of changes in grades or other reasons. Contractor shall replace dislocated survey control points based on original survey control at no cost to the Owner.

D. Contractor shall install and maintain temporary benchmarks located near the work site in a location free of potential vehicular traffic. Contractor shall determine horizontal coordinates of the benchmark to an accuracy of ±0.25 ft relative to the site coordinate system and the elevation to an accuracy of ±0.1 ft NGVD (National Geodetic Vertical Datum, 1929).

SECTION 02100

EROSION CONTROL

SECTION 02100

EROSION CONTROL

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnish labor, equipment and materials as specified herein to erect, maintain and remove a temporary sediment barrier or equivalent attached to supporting posts and entrenched.

B. Contractor shall be responsible for prevention of runoff from site causing erosion products to be deposited at locations outside the limits of the work.

C. Contractor shall collect eroded materials from their off-site locations and return these to the site.

D. Contractor shall be responsible for repairing and restoring erosion which occurred during construction to original conditions.

1.2 SUBMITTALS

A. Contractor shall prepare an Erosion and Sediment Control Plan that is in accordance with the standards and requirements of the Illinois Environmental Protection Agency.

B. Contractor shall submit this Erosion and Sediment Control Plan for approval by the Construction Manager.

1.3 LOCATIONS FOR USE

A. Below disturbed areas where sheet and/or fill erosion may occur.

B. At locations hydraulically downgradient of site construction activities and at locations indicated on the Plans.

C. At locations selected by the Construction Manager to prevent sediment migration.

PART 2 PRODUCTS

2.1 MATERIALS

A. Geotextile (filter) shall be a pervious sheet of propylene, nylon, polyester or ethylene yarn.

B. Geotextile (filter) shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable exposed life at a temperature range of 0° to 120° F.

C. Stakes for silt fences shall be 1" x 2" wood (preferred) or equivalent metal with a minimum length equal to the height of silt fence plus 12 inches.

D. Contractor may identify alternate materials for erosion control. Alternate materials shall be submitted to the Construction Manager for evaluation of equivalency prior to installation.

PART 3 EXECUTION

3.1 REQUIREMENTS

A. Erosion control devices shall be installed as depicted on the Drawings.

B. Best Management Practices shall be utilized in the installation of the devices to prevent and/or correct problems related to the transport of material or soil by runoff water particularly from construction and other land disturbing activities.

C. All devices shall be installed in accordance with the standards and requirements of the Illinois Environmental Protection Agency or as required by the Drawings or Specifications.

D. Requests for deviations from the approved Erosion and Sediment Control plan must be submitted in writing to the Construction Manager.

3.2 INSTALLATION

A. The geotextile shall be delivered to the jobsite in a continuous roll and cut to the length of the barrier to avoid the use of joints. When joints are necessary, it shall be spliced together only at a support post, with a minimum 6-inch overlay, and securely sealed.

B. Posts shall be spaced a maximum of 6 feet apart at the barrier location and driven securely into the ground a minimum of 12 inches.

C. A trench shall be excavated upslope from the barrier approximately 4" x 4" deep along the line of posts.

D. Geotextile shall be stapled or wired to the fence, and 8 inches of the fabric shall be extended in to the trench. The fabric shall not extend more than 36 inches above the original ground surface.

E. The trench shall be backfilled over the filter fabric.

F. Silt fences shall be removed when they have served their useful purpose, but not before the upslope area construction is completed.

3.3 MAINTENANCE DURING CONSTRUCTION

A. The Contractor shall inspect erosion prevention measures immediately after each rainfall and at least daily during prolonged rainfall. Required repairs shall be made immediately.

B. If the geotextile on a silt fence decomposes or become ineffective prior to the end of the desired use, the Contractor shall replace the fabric promptly.

C. Sediment and other erosion products deposited against the barrier shall be checked after each storm event. They must be removed when deposits reach approximately ½ the height of the barrier, or if deformation of the barrier has occurred.

D. Any sediment deposits remaining in place after the silt fence or barrier is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

END OF SECTION 02100

SECTION 02150

STORMWATER CONTROL DURING CONSTRUCTION

SECTION 02150

STORMWATER CONTROL DURING CONTRUCTION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Maintain adequate site drainage.

B. Collection and routing of stormwater.

1.2 SUBMITTALS

A. Contractor shall develop a Stormwater Control Plan in accordance with the standards and requirements of the Illinois Environmental Protection Agency.

B. Contractor shall submit the Stormwater Control Plan for Construction Manager approval.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 SURFACE WATER CONTROL

A. Contractor shall furnish, install, maintain and operate all equipment and materials needed to prevent, control and remove surface water within or adjacent to the area of work.

B. Contractor shall provide and maintain berms, curbs, surface drainage swales or runs as necessary, to prevent surface water from entering fill placement areas.

C. Contractor shall immediately remove impounded water that affects any area of the Work.

D. Stormwater pumped from within the landfill berms shall be discharged in accordance with the approved Stormwater Management Plan. Contractor may propose above ground temporary water holding areas in the Stormwater Management Plan.

3.2 GROUND WATER CONTROL

A. Contractor shall furnish, install, maintain, and operate all equipment and materials to prevent ground water from flowing into excavations or onto work areas or areas designated to receive fill.

B. Collected groundwater must be stored and tested by the Contractor to determine if it contains hazardous constituents and/or is a hazardous waste. After testing, the collected groundwater must be disposed in a manner consistent with relevant and appropriate regulations.

3.3 MAINTENANCE DURING CONSTRUCTION

A. The Contractor shall maintain adequate drainage of construction work areas of the site during progress of the work such that ponding of rainwater does not occur.

B. Stormwater drainage shall be diverted away from the construction and work areas of the site.

C. Stormwater control measures shall fully comply with the approved Stormwater Control Plan.

END OF SECTION 02150

SECTION 02175

CLEARING AND GRUBBING

SECTION 02175

CLEARING AND GRUBBING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnish labor, equipment and materials as required to clear and grub existing vegetation from areas designated as Borrow Areas and Temporary Haul Road(s).

B. Removal and disposal of vegetation generated by the Clearing and Grubbing activities.

1.2 RELATED SECTIONS

A. Section 02190 - Borrow Areas and Temporary Haul Road(s).

B. Section 01050 - Construction Survey

C. Section 02100 - Erosion Control

D. Section 02150 - Stormwater Control During Construction

E. Section 02200 - Earthwork

1.3 SUBMITTALS

A. Contractor shall submit a Clearing and Grubbing Plan that is consistent with the selected locations for the construction areas and temporary haul road(s).

B. Contractor shall secure any and all required permits to remove, transfer and dispose of materials generated during Clearing and Grubbing activities. This includes any materials deemed salvageable or suitable for reuse outside of the Owner's property.

C. Contractor shall include Clearing and Grubbing in the Erosion Control Plan as required by Section 02100.

D. Contractor shall include Clearing and Grubbing in the Stormwater Control Plan as required by Section 02150.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 EXISTING CONDITIONS

A. Contractor shall protect bench marks/monuments, reference points, designated monitoring wells and all utilities shown on the drawings. Reference Section 02200-1.6 Earthwork, Protection.

B. Contractor shall insure that all roads remain uninterrupted during the work. Any encroachment or potential impact to facilities must be coordinated for approval through the Construction Manager.

3.2 IMPLEMENTATION

A. Clearing: Clearing shall consist of the removal and disposition of standing trees and snags, stumps, boulders, brush, down timber, logs and other growth, and objects on and above the ground surface. Cleared materials shall be disposed of in areas designated on the drawings or at locations mutually selected by the Contractor and approved by the Construction Manager.

B. Grubbing: Grubbing shall consist of the removal of stumps, roots, buried logs, boulders, and other deleterious materials below the ground surface within the limits of the designated construction areas and haul road locations. Stumps, roots over 1.0 inch in diameter, buried logs, and boulders shall be removed completely. The grubbed area shall be managed in a manner as to prevent any of the above listed vegetation or objects to be transported to the Landfill construction placement area.

C. Disposal: Cleared and grubbed materials shall be placed in designated locations shown on the drawings. All materials generated during the Clearing and Grubbing process shall be disposed of outside of the designated limits of the construction areas and haul road(s). Material stockpile locations may be agreed to during the work, by Contractor and Construction Manager, if the selected locations provide mutual benefit and do not impact future use of the selected areas. Onsite burning is not permitted.

D. Limbs, brush, and branches shall be chipped by mechanical chipping machine and stockpiled outside of the limits of the construction area. Tree trunks and logs shall be piled or stacked outside of the perimeter of the construction area.

3.2 MAINTENANCE DURING CONSTRUCTION

A. Contractor shall promptly remove cleared and grubbed materials from any active work area.

B. Surface areas disturbed during the work shall be graded to establish smooth contours, provide stable slopes, and promote controlled drainage.

C. Clearing and Grubbing activities shall be conducted in such manner as to promote the efficient and expedient utilization of the construction areas and temporary haul road(s).

END OF SECTION 02175

SECTION 02190

TEMPORARY HAUL ROADS

SECTION 02190

TEMPORARY HAUL ROADS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnish labor, equipment and materials as specified herein to develop, utilize and maintain the temporary transfer haul roads.

B. Contractor shall be responsible for survey layout, site preparation, excavation, material transfer and maintenance of the haul road(s).

1.2 RELATED SECTIONS

A. Section 01050 - Construction Survey

B. Section 02100 - Erosion Control

C. Section 02150 - Stormwater Control During Construction

D. Section 02175 – Clearing and Grubbing

E. Section 02200 - Earthwork

1.3 SUBMITTALS

A. Contractor shall include the Temporary Haul Roads in the Sediment and Erosion Control Plan and the Stormwater Control Plan as required by Section 02100 and Section 02150.

B. Contractor shall prepare layout drawings of the proposed location(s) of the proposed Temporary Haul Road(s) that conform to the requirements of the Drawings.

C. Contractor shall include the Temporary Haul Road(s) in the Construction Plan as required by Section 02200 - Earthwork. In addition to the listed requirements, Contractor shall include the location(s) and estimated quantities of roadway drainage culverts, roadway fill and cut sections, and all other appurtenances and materials deemed necessary by the Contractor for the development of the facilities.

D. The Contractor shall submit this information to the Construction Manager for approval prior to implementation.

1.4 TESTING

A. Testing shall be in accordance with the provisions of Section 02200 - Earthwork.

PART 2 EXECUTION

2.1 PREPARATION

A. Contractor shall prepare the area by Clearing and Grubbing in accordance with Section 02175.

B. The Construction Manager shall approve the Contractors Construction Plan prior to commencement of the work.

2.2 EXCAVATION

A. All excavations shall comply with the requirements of OSHA 29 CFR Part 1926.

B. Temporary cut slopes shall not be steeper than 1 horizontal to 1 vertical. Finished slopes, left for final grading and long- term maintenance, shall not be steeper than 3:1 horizontal to vertical distance.

C. Site restoration will <u>not</u> include removal of the Temporary Haul Roads. Temporary Haul Roads shall be left graded to properly drain and all culverts and appurtenances that have become an integral part of the road shall become the property of the Owner.

D. Contractor shall seed and mulch all disturbed areas following final grading as outlined in Section 2.2, B, of this specification.

2.3 MAINTANENCE and PROTECTION DURING CONSTRUCTION

A. Contractor shall maintain the Temporary Haul Roads in accordance with the provisions of Section 02100 - Erosion Control and Section 02150 - Stormwater Control.

B. Contractor shall provide all Traffic and Safety controls as required by Section 02200 - Earthwork.

C. Effective Dust Control Measures must be employed at all times, in all areas of the work. Contractor shall include any and all dust suppression measures that are necessary for workers health and safety and for the health and safety of persons on or adjacent to the Owner's property. Dust Control Measures may include, but are not limited to: watering spray trucks, approved chemical dust suppressants, road grading, or surface treatments, such as gravel. The Construction Manager shall approve all proposed dust control methods and may request additional control measures if site conditions begin to effect visibility, traffic safety or workers breathing areas.

PART 3 QUALITY CONTROL

3.1 REQUIREMENTS

A. Contractor shall be responsible for constructing temporary haul roads that adequately serve all construction and waste placement needs throughout the project duration. All road maintenance shall be the responsibility of the Contractor.

END OF SECTION 02190

SECTION 02200

EARTHWORK

SECTION 02200

EARTHWORK

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section describes general earthwork requirements for site preparation, perimeter berms, insitu soil compaction, soil protection, sand drainage layer, gravel fill, vegetative cover soil, and related activities. This section does not include sediment handling and placement.

1.2 REFERENCES

A. ASTM D75 - Practice for Sampling Aggregates.

B. ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.

C. ASTM D422 - Method for Particle-Size Analysis of Soils.

D. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).

E. ASTM D1556 - Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

F. ASTM D2167 - Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.

G. ASTM D2216 - Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.

H. ASTM D2434 - Test Method for Permeability of Granular Soils.

I. ASTM D2487 - Classification of Soils for Engineering Purposes.

J. ASTM D2922 - Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

K. ASTM D2937 - Test Method for Density of Soil in Place by the Drive Cylinder Method.

L. ASTM D3017 - Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

M. ASTM D4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

N. ASTM D1140 - Test Method for Amount of Material in Soils Finer than the No. 200 Sieve.

O. ASTM D5084 - Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Perimeter.

1.3 DEFINITIONS

A. Well-Graded: A mixture of particle sizes that has no specific concentration, or lack thereof, of one or more sizes. A material type that, when compacted, produces a strong and relatively incompressible soil mass.

B. Coverage: One coverage is defined as the requirement of successive trips of a piece of compaction equipment, which by means of sufficient overlap, will ensure that all areas of the layer being compacted have been subjected to one pass of the compaction equipment.

C. Optimum Moisture Content: The maximum moisture content that will result when plotted against the dry unit weight of a soil when subjected to the ASTM D698 compaction test.

D. Percent Compaction: The percent compaction in-place shall be calculated as the ratio (in percent) of the in-place dry density to the estimated maximum dry density, in accordance with ASTM D698, of the representative fill material at the location of the in-place density test.

E. Proof Rolling: Rolling a surface with a minimum of 3 passes with approved compaction equipment for the purpose of detecting soft or loose areas.

F. On-Site Soils: On-site soils are defined as the insitu material located within the footprint of the liner system and the perimeter berms.

G. Borrow Soils: borrow soils are defined as material transferred to the footprint area from a remote location.

H. Unsuitable Materials: All soil materials that contain waste, debris, roots, organic matter, frozen matter, stone or rock with any dimension greater than 1-inch, or any other material that are determined by the Construction Manager to be unsuitable for stable, compacted backfill purposes. Approved on-site borrow soils are suitable fill.

I. Borrow Areas: Borrow areas are those locations approved by the Construction Manager for procurement, excavation and use of materials for Construction of the Perimeter Containment Levee, Final Cover or landfill soil components. Borrow areas do not include "on-site soils" as defined herein.

J. Fine-Grained Soils: Fined grained soils are defined as those materials which pass a 200 sieve in accordance with the guidelines established in ASTM C136.

1.4 TESTING

A. The Contractor will retain the services of a QC testing laboratory that has been approved by Construction Manager to perform tests as specified herein. At a minimum, the Contractor shall be responsible for providing QC for the following:

1. Compliance testing for materials provided from onsite and offsite sources.

2. QC testing and inspection during construction.

B. The Contractor shall inspect and verify all earthwork operations are in conformance with this specification and the contract documents. Moisture/density relationships for the various fill materials will be established as part of the QC program. Field density tests, sample selection, and construction observations will be performed in sufficient numbers and in such locations to verify that the specified density is being achieved.

C. The Contractor shall inform the Construction Manager prior to conducting all field tests to allow oversight. No additional fill placement shall be permitted in areas that have not met the specified fill placement criteria.

1.5 SUBMITTALS

A. Construction Plan

The Contractor shall submit a construction plan identifying the procedures and methods to be used. The plan shall be approved by the Construction Manager prior to any earthwork activities. The construction plan shall, at a minimum, include the following:

1. Proposed material source(s) and proposed method(s) of sampling.

2. Proposed soil processing, placement, compaction, and moisture control equipment, including equipment catalog with weight, dimensions, and operating data for all equipment.
3. Proposed locations of soil processing and moisture control.

4. Proposed methods for soil processing and moisture control.

5. Proposed work schedule.

6. Proposed method of protecting Work, to include temporary drainage measures.

7. Proposed QC Personnel. All QC personnel shall demonstrate specific experience of at least 2 years in the areas in which they will be performing QC inspections.

8. Proposed professional engineer registered in Illinois with no less than 5 years experience in the performance and evaluation of geotechnical laboratory tests on constructed materials.

9. Proposed land surveyor licensed in the State of Illinois.

10. Proposed excavation, stockpiling, regrading and staging plan describing handling and transport of borrow materials.

11. Proposed proof rolling method and equipment for each subgrade condition.

B. Contractor shall submit results of prequalification test data on each material source to the Construction Manager for approval prior to procurement, excavation, transport, stockpiling or use.

C. Contractor shall submit results of all field and laboratory prequalification and quality control data to the Construction Manager within 1 work day of receipt.

D. Contractor shall submit the results of all observations and documentation generated by its quality control personnel the next work day.

E. Contractor shall submit results of all field surveys and documentation to the Construction Manager. Copies of surveyor field data, books and notes shall be submitted within 1 work day of generation. Copies of survey information signed and sealed by a Florida licensed surveyor shall be submitted within 1 work day of receipt.

1.6 PROTECTION

A. All streets, roads, grading, structures, utilities and other improvements not specifically designated to be cleared, removed, stripped or altered as a part of the work shall be protected from damage throughout the construction period. Any damage caused by the Contractor, his employees, agents, or any lower tiered subcontractors shall be immediately repaired to the original condition and to the satisfaction of the Construction Manager at no additional cost to the Owner.

B. Traffic Control

1. Keep all roads, sidewalks, and parking areas that are not part of this project usable at all times.

2. The Contractor shall provide all necessary barricades, lights, signs, signals, etc., for the protection of the workers and the public, as established by the Occupational Safety and Health Administration (OSHA) Construction Safety and Health Regulation 29 CFR, Part 1926, Subpart G, Signs, Signals and Barricades, and in Subpart P- Excavations, trenching and shoring, and IDOT Standard Specifications for Highway Construction, latest edition.

C. Existing Utilities

1. The Contractor is solely responsible for identification of all utilities, both known and unknown.

2. Known existing utilities are indicated on the Plans. The Contractor shall hand excavate areas within 6 feet (ft) of existing utilities. Any requested variance from the hand excavation requirement shall be submitted in writing to the Construction Manager.

3. Actual locations of all existing utilities within the work area shall be located by the Contractor by hand excavation and indicated on the As-Built drawings.

4. After the actual locations and routing of the existing utilities have been found to be accurately determined through this hand excavation, and after approval from the Construction Manager, the Contractor may begin excavation using machinery in a manner acceptable to the Construction Manager.

5. After excavation by machinery has begun, the Contractor shall be fully responsible for all utilities that were found through hand excavation and/or which were indicated on the Drawings.

6. Any existing utility indicated on the Drawings that is damaged by the Contractor shall be immediately repaired to its previous undamaged condition at no additional cost to the Owner.

7. Notify the Construction Manager immediately of any encountered utilities not shown on the Drawings.

8. Obtain approval from the Construction Manager before backfilling in areas of known utilities. Utility warning tape (provided by the Contractor) shall be placed 12 inches above existing or newly installed utilities.

D. Monitoring Wells

1. Contractor shall be solely responsible for identification of all groundwater monitoring wells.

2. Known groundwater monitoring wells are indicated on the Plans. Contractor shall not operate machinery, excavate, mound soil or otherwise disturb the ground surface around a monitoring well without the concurrence of the Construction Manager.

3. Contractor shall be solely responsible for the protection and usability of the monitoring wells during the work.

4. If the Contractor damages a monitoring well during the performance of the work, the Contractor shall immediately notify the Construction Manager of the damage.

5. If the Owner subsequently determines that the damaged monitoring well no longer performs satisfactorily, the Owner will have the well repaired, replaced or abandoned by a qualified well installer and will recover any resulting cost from the Contractor.

6. Repair , replacement or abandonment procedures shall be those required by the Northwest Water Management District. Repair, replacement and/or abandonment procedures shall include all fees and documentation required by the Water Management District.

1.7 REGULATORY REQUIREMENTS

A. Permits

Obtain and comply with all appropriate local, state, and federal permits and licenses required for performing the work.

PART 2 PRODUCTS

2.1 ON-SITE SOILS

A. Soils in the vicinity of the Landfill contain a limited amount of organic and inorganic constituents. Excavation and removal of onsite or surrounding soils is not permitted unless approved by the Construction Manager.

B. Pockets, lenses or layers of material differing in texture, gradation, moisture or density from the surrounding material shall be identified and removed with the concurrence of the Construction Manger. Removed materials shall be replaced with

Compacted Fill in accordance with the requirements of the Specifications. Removed materials shall be disposed in the manner and location designated by the Construction Manager.

2.2 BORROW SOURCES

A. Borrow sources do not exist within the property boundary of the proposed landfill for use on this project.

B. Borrow sources may not be available within the Plant boundaries for the Drainage Material or the Vegetated Cover Fill.

C. Offsite Sources

1. Contractor shall be responsible for locating sources of borrow material from offsite sources sufficient to complete the work. The Contractor shall obtain representative samples of the proposed source for laboratory testing. Results of the testing along with representative samples of the proposed material shall be submitted to the Construction Manager for approval prior to procurement, excavation, transport stockpiling or use.

2. Contractor use of other borrow sources shall only be with the written approval of the Construction Manager. Unless otherwise directed by the Construction Manager all material shall conform to the requirements of the Specifications.

3. Contractor shall be responsible for conducting TCL/TAL testing of borrow soils in accordance with the latest IEPA requirements. Off-site borrow shall be tested at a rate of one sample per 5,000 cubic yards of material excavated. Contractor shall compare the test results with TACO Tier I criteria for commercial / industrial area soils. The test results and the comparison to TACO criteria shall be submitted to the Construction Manager and CQA Consultant for review and approval. Any borrow soils containing TCL/TAL contaminants above the Tier I levels shall not be acceptable for landfill construction.

2.3 FILL MATERIAL

A. Compacted Fill

1. Compacted Fill shall consist of random granular or cohesive materials obtained from approved on-site or off-site borrow areas. Compacted Fill will contain a minimum of 5 percent by dry weight of material passing the U.S. No. 200 Sieve and be free of lenses, pockets or layers of material differing in texture, gradation, and moisture from surrounding material. Compacted Fill shall consist of soil types meeting the following classifications of ASTM D2487:

2. The maximum clod size for Compacted Fill shall be 4 inches in any dimension. Oversize material shall be removed or reworked to conform to these requirements. Non-uniform material shall be removed or reworked to conform to these requirements.

B. Tracked In-place Fill

1. Tracked In-place Fill shall consist of poorly graded granular or cohesive fill obtained from approved borrow areas. Tracked In-place Fill shall be free from lenses, pockets or layers of material differing in texture, gradation, and moisture from surrounding material.

4. Tracked In-place Fill shall consist of soils types meeting the following classifications of ASTM D2487:

Silty to Clayey Sands	SC, SP, SP-SM, SC-SM
Silty Sands	SM, SP
Clayey Silts to Silty Clays	SC-SM, SM-SC, CL
Silty Sandy Clays	CL
Combinations of the above	

3. The maximum clod size for Tracked In-place Fill shall be 2 inches in any dimension. Oversize material shall be removed or reworked to conform to these requirements. Non-uniform material shall be removed or reworked to conform to these requirements.

C. Drainage Material

1. Drainage material shall consist of siliceous, non-carbonate, non-angular sound sand or gravel obtained from approved borrow sources. Drainage material will contain a maximum of 10 percent by dry weight of material passing the U.S. No. 100 Sieve and be free of lenses, pockets or layers of material differing in texture, gradation and moisture from the surrounding material.

2. Sand drainage material shall consist of soil types meeting the following classifications of ASTM D2487:

Slightly Silty Sands	SM, SP-SM, SW-SM
Well Graded to Poorly Graded Sands	SP, SW

Sand drainage material shall conform to the following ASTM C33 requirements for fine aggregates:

Sieve Size	Percent Passing by Weight
3/8 inch	100
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	10 – 30
No. 100	0 – 10

Sand drainage material shall have a laboratory measured permeability of ≥ 1 x 10^{-3} cm/sec.

3. Gravel drainage material shall consist of soil types meeting the following classifications of ASTM D2487.

Sandy Gravel to Sandy Silty Gravel	GW-GM, GP-GM
Well Graded to Poorly Graded Gravel	GW, GP

Gravel drainage material shall conform to the following ASTM C33 requirements for coarse aggregates:

Sieve Size	Percent Passing by Weight
1.5 inch	100
1 inch	95 – 100
½ inch	25 – 60
No. 4	0 – 10
No. 8	0 – 5

Gravel drainage material shall have a laboratory measured permeability of ≥ 1 cm/sec.

D. Protection Layer

1. Protection Layer shall consist of granular or fine-grained materials obtained from approved borrow areas, or other sources as approved by the Construction Manager. Protection Layer will be used to construct the protective soil layer placed directly on the Primary Collection System. Protection Layer shall consist of soil types meeting the following classifications:

Silty to Clayey Sands	SC, SP, SP-SM, SC-SM
Poor to Well Graded Sands	SP, SW
Sandy to Silty Clays	SM-SC
Creek Sediments	

2. Protection Layer shall be free of rocks, sticks, roots deleterious or unsuitable materials. Maximum clod size for protective fill shall be 2 inches in any dimension. Oversize material shall be removed or reworked to conform to these requirements. Non-uniform material shall be removed or reworked to conform to these requirements.

E. Vegetated Cover Fill

1. Vegetated Cover Fill shall consist of granular material obtained from approved borrow areas. Vegetated Cover Fill will contain a maximum of 15 percent by dry weight of material passing the U.S. No. 200 Sieve and be free from lenses, pockets or layers of material differing in texture, gradation, and moisture from surrounding material. The Vegetated Cover Fill shall have a laboratory measured permeability $\geq 1 \times 10^{-3}$ cm/sec. Vegetated Cover Fill shall consist of soil types meeting the following classifications of ASTM D2487:

Silty Sands	SM
Clayey Sands	SC, CL-SC
Silty to Clayey Sand	SP-SM, SP-SC, SC-SM
Topsoil	
Combinations of the above	

2. The maximum clod size for vegetated cover shall be 2 inches in any dimension. Oversize material shall be removed or reworked to conform to these requirements. Non-uniform material shall be removed or reworked to conform to these requirements.

3. Vegetated Cover Fill shall conform to the following gradation requirements:

Sieve Size	**Percent Passing by Weight**
No. 16	100
No. 30	90 – 100
No. 50	60 – 100
No. 100	25 – 80
No. 200	5 – 40

2.4 EQUIPMENT

A. All equipment and tools used in the performance of this work are subject to the approval of the Construction Manager before work is started.

B. Contractor shall provide compaction equipment appropriate for the material types to obtain the densities specified. At a minimum "footed" rollers are expected for compaction of fine-grained soils or cohesive fills. Smooth drum rollers or hand compaction methods may be appropriate for granular drainage material sands and gravels.

C. Contractor shall provide hand-operated compaction equipment in areas closer than 2 ft from pipes or other appurtenant structures to obtain the densities specified.

D. Contractor shall operate and maintain compaction equipment in accordance with the manufacturer's instructions and recommendations. If inadequate densities are obtained, provide larger and/or different type equipment at no cost to the Owner.

E. Contractor shall provide equipment for applying water of a type and quality adequate for the Work, free of leaks and equipped with a distributor bar or other approved device to ensure uniform application.

F Contractor shall provide equipment for mixing and drying out material, such as blades, discs, or other approved equipment.

G. Contractor shall sufficiently weigh the compaction equipment such that the feet fully penetrate the loose lift during initial compaction.

H. Contractors mixing and blending equipment shall fully penetrate loose lifts during mixing to achieve a uniform material.

I. Contractor shall provide steel drum rollers to prepare the surface of placed or compacted fill prior to placement of geosynthetic materials.

PART 3 EXECUTION

3.1 WATER CONTROL

A. Contractor shall furnish, install, maintain and operate all equipment and materials needed to prevent, control and remove surface water within or adjacent to the area of work in accordance with the approved Stormwater Control Plan identified in Section 02150 of these Specifications.

B. Contractor shall furnish, install, maintain, and operate all equipment and materials to prevent ground water from flowing into excavations or onto work areas or areas designated to receive fill as necessary or as required by the Construction Manager.

3.2 CLEARING AND GRUBBING - LANDFILL FOOTPRINT AREA

A. Contractor shall remove vegetation including snags, brush, and rubbish occurring in the areas of the work.

B. Roots, brush, rotten wood, and other refuse collected by the Contractor from the clearing and grubbing operations shall be disposed by the Contractor at the designated location shown on the Drawings.

3.3 SUBGRADE PREPARATION

A. General

1. Contractor shall proof roll footprint areas as shown on the Plans to identify soft or spongy areas.

2. Contractor shall remove soft or spongy areas and replace with Compacted Fill. Low spots and depressions shall be backfilled to achieve a uniform grade.

3. Contractor shall spread out excavated subgrade soils for drying and blending with onsite soils within the footprint of the landfill unless Contractor's written request for options are approved.

B. Perimeter Berms and Liner System Footprint

1. Contractor shall disc, harrow and breakup subgrade soils to a depth of 8 inches within the perimeter berm and liner system footprint.

2. Contractor shall prepare subgrade soils to meet the requirements of Compacted Fill.

3. Soils not meeting the requirements of Compacted Fill shall be removed and replaced by the Contractor.

4. Contractor shall adjust in-place soils moisture content to be no less than 2 percent below optimum and no more than 3 percent above optimum as determined by ASTM D698.

5. Contractor shall compact insitu soils to not less than 95 percent of the laboratory maximum Standard Proctor dry density (ASTM D698). Any single in-place density test falling below 90 percent compaction level shall be classified as a failing test and the area of materials represented by the failing test shall be re-processed by the Contractor until 95 percent or greater compaction is achieved. Areas represented by in-place density test results falling between 90 and 95

percent maximum Standard Proctor dry density may be accepted if both of the following conditions are met:

(a) The test result is not more than 1 in 5 successive tests in the range of 90 to 95 percent maximum density.

(b) Total number of in-place density tests falling in the range of 90 to 95 percent maximum dry density is less than 10 percent of the total number of in-place density tests completed at that time.

Areas represented by unacceptable tests with compactions between 90 and 95 percent shall be reprocessed by the Contractor until 95 percent or greater maximum dry density is achieved.

3.4 SURFACE PREPARATION

A. The compacted surface of any layer of fill which is too wet or too dry for bonding to the next layer of material shall be dried or moistened by the Contractor and compacted before the next layer is placed.

B. Contractor shall scarify the foundation so that the surface materials will bond and compact with the first layer of fill.

C. Contractor shall place all fill to conform to the grades and cross-sections shown on the Plans.

3.5 EXCAVATION

A. All excavation shall comply with the requirements of OSHA 29 CFR Part 1926.

B. Limits

1. Contractor shall excavate to lines, grades, and dimensions, as shown on the Plans.

2. Contractor shall minimize excavation beyond limits shown unless otherwise approved in writing by the Construction Manager.

3. Contractor shall design and use sloping, sheeting, shoring and bracing as necessary to protect existing structures from damage.

4. Contractor shall grade the surface of overexcavated areas by creating a smooth transition to adjoining areas, and slope to drain.

5. Overexcavated areas shall be backfilled and compacted by the Contractor in accordance with these specifications at no expense to the Owner unless additional excavation was previously approved by the Construction Manager.

C. At the conclusion of each days work, Contractor shall backfill, barricade or adequately fence and protect all trenches and/or excavations in accordance with the Owner's EH&S Requirements.

3.6 PLACEMENT

A. General

1. Contractor shall construct the soil components of the lining and final cover system using suitable fill materials as specified.

2. Contractor shall construct soil components to the lines and grades shown on the Plans.

3. Contractor shall construct each layer of each zone in a continuous and nearly horizontal layer for the full width at the elevation of the layer unless otherwise required by the Specifications or Plans.

4. Contractor shall place and compact all materials to prevent constructed discontinuities in the fill or segregated areas of the work. Differences in elevation for Compacted Fill shall not exceed four (4) ft unless otherwise approved in writing by the Construction Manager. Individual lifts are required to be placed and compacted per Section 3.6.B of these Specifications.

5. Special care shall be taken by the Contractor to ensure bonding of new fill to constructed segments previously placed by benching in 2 ft horizontally into the existing fill for each 1-ft vertical placement. This requirement shall not apply to construction interfaces between side slopes and bottom materials.

6. Contractor shall moisten or aerate, scarify, and work with harrows, discs, or other suitable equipment in such a manner to reduce the clod size of material being placed to the requirements given. Blend all material to be free from lenses, pockets, or layers of material differing in texture, gradation, and moisture from surrounding materials and to depths that provide a bonding surface with the new material.

7. Soils with excess moisture shall be sufficiently dried to meet the specified compaction requirements.

8. Contractor may at his option add moisture to the borrow area.

B. Compacted Fill

1. Prior to placing any new fill, the Contractor shall scarify the foundation upon which new fill is to be placed. Where the proposed fills overlie unsuitable materials, such materials shall be removed by the Contractor.

2. Contractor shall ensure the uniform moisture distribution of the Compacted Fill.

3. Materials too dry for compaction may be pre-wetted in the borrow areas by the Contractor. Supplemental water, if required, may be added by the Contractor to the material after placement and prior to compaction by uniform sprinkling and shall be mixed uniformly using discs.

4. Contractor shall conduct borrow and placing operations to assure product uniformity.

5. The material shall be placed by the Contractor in maximum 12-inch thick (loose) lifts.

6. The placement moisture content for Compacted Fill zone materials shall be between 2 percent below and 3 percent above optimum moisture content (ASTM D698).

7. Compacted Fill shall be compacted by the Contractor to not less than 95 percent of the laboratory maximum Standard Proctor dry density (ASTM D698). Any single in-place density test falling below 90 percent compaction level shall be classified as a failing test and the area of materials represented by the failing test shall be be-processed by the Contractor until 95 percent compaction is achieved. Areas represented by in-place density test results falling between 90 and 95 percent maximum Standard Proctor dry density may be accepted if both of the following conditions are met:

   (a) The test result is not more than 1 in 5 successive tests in the range of 90 to 95 percent maximum density.

   (b) The total number of in-place density tests falling between 90 to 95 percent maximum dry density is less than 10 percent of the total number of in-place density tests completed at that time.

   Areas represented by unacceptable tests with compactions between 90 and 95 percent shall be reprocessed by the Contractor until 95 percent or greater maximum dry density is achieved.

8. The Contractor shall route all construction equipment in a manner that ensures uniform compaction of each lift.

9. Lift thickness shall be controlled by the Contractor through the use of temporary grade stakes.

10. If the compacted surface of any completed lift of fill is too wet or too dry for placement of the subsequent lift, it shall be dried back or moistened, and then scarified before the next lift of fill is placed. Contractor shall remove grade stakes from the fill prior to compacting that lift.

11. Contractor shall protect and maintain a smooth finished surface on the embankment prior to seeding with vegetative cover.

12. Erosion gullies, rills or other surface discontinuity developing on the exterior face of the embankment shall be repaired by the Contractor immediately.

13. Erosion features which average 2 inches deep or less shall be repaired by the Contractor by reblading and compacting the surface.

14. Erosion features which average greater than 6 inches deep shall be removed by the Contractor and replaced using procedures acceptable to the Construction Manager.

C. Tracked In-place Fill

1. Tracked In-place Fill shall be placed by the Contractor to the lines and grades shown in the Plans.

2. Soil material shall conform to the material requirements of these Specifications for Tracked In-place Fill.

3. The Contractor shall place the first lift of Tracked In-place Fill over the geosynthetic material (i.e., geomembrane liner) in a uniform loose lift no less than 12 inches thick by track-mounted earthmoving equipment. All fill shall be "rolled" into place such that fill placement shall not "gouge" or displace the lower materials.

4. The first lift of the Tracked In-place Fill will be inspected and tested. If the in-place density and moisture content meet the requirements of the Specifications, either all or a portion of the first lift will be accepted.

5. Prior to placement of subsequent lifts, the Contractor shall sufficiently roughen the area to a depth of approximately 2 inches. Fill moisture content shall be modified as necessary to provide a suitable bond with the next lift.

6. Contractor shall spread subsequent fill in uniform lifts not exceeding 9 inches in loose thickness before compaction.

7. Contractor shall adjust moisture content as required to maintain the range specified. Moisture content adjustment shall be accomplished by aerating and discing when too wet or by adding water and mixing by discing or blading when too dry. The addition of water to the clay fill shall utilize thorough mixing to achieve a uniform moisture content distribution within the Tracked In-place Fill.

8. Contractor shall compact Tracked In-place Fill to no less than 90 percent of the laboratory maximum Standard Proctor dry density as per ASTM D698.

9. The placement moisture content shall be optimum or above optimum moisture content as determined by ASTM D698.

10. Contractor shall not permit equipment to travel directly on geosynthetic material.

D. Drainage Material

1. Contractor shall place Drainage Materials to the lines and grades shown in the Plans.

2. Drainage Material shall conform to the material requirements for Sand Drainage or Gravel Drainage Material or Capillary Break Layer in these Specifications.

3. Contractor shall prevent soils from adjacent zones being tracked or mixed with Drainage Material Fill.

4. Contractor shall loosely dump and "roll" Sand Drainage Material into place without sliding or gouging underlying material.

5. Contractor shall place Sand Drainage Material in uniform horizontal lifts no less than 12 inches thick prior to compaction.

6. Contractor shall compact Sand Drainage layer to 50 percent relative density.

7. Contractor shall place Gravel Drainage Fill in uniform lifts. Contractor shall not dump gravel on geosynthetic materials.

8. Contractor shall not permit equipment to travel directly on geosynthetic material.

E. Protection Layer

1. Contractor shall place Protection Layer to the lines and grades shown in the Plans.

2. Protection Layer shall conform to the requirements of these Specifications.

3. Contractor shall place Protection Layer in uniform loose lifts. Contractor shall "roll" Protection Layer into place without gouging underlying materials.

4. Protection Layer shall be walked into place using track-mounted equipment.

5. Contractor shall not permit equipment to travel directly on geosynthetic material.

F. Vegetated Cover Fill

1. Contractor shall place Vegetated Cover to the lines and grades shown on the Plans.

2. Contractor shall place first lift of Vegetated Cover in uniform horizontal lifts of 12 inches.

3. Contractor shall "roll" Vegetated Cover Fill into place without gouging underlying layers using tracked equipment with ground pressures less than 5 psi.

4. Each lift of Vegetated Cover Fill shall be compacted by the Contractor with no less than 3 coverages using tracked equipment.

5. Contractor shall not permit equipment to directly travel across geosynthetic material.

3.7 PREPARATION FOR GEOSYNTHETIC MATERIAL PLACEMENT

A. Contractor shall trim all surfaces and areas to receive geosynthetic materials to achieve a smooth uniform grade, free from sharp edges, ruts or discontinuities.

B. Contractor shall condition the upper six inches of surface soil in all areas to receive geosynthetic materials with water as necessary to achieve a moisture content of approximately optimum as determined by ASTM D 698.

C. Contractor shall smooth drum roll all areas after moisture conditioning is complete. Soft or spongy areas of fill shall be removed at the direction of the Construction Manager and replaced in accordance with the requirements of these specifications at no cost to the Owner.

D. Contractor shall certify to the Construction Manager that all areas to receive geosynthetic materials area free from sharp edges, ruts or discontinuities.

E. Prior to releasing an area for geosynthetic placement, the Construction Manager or his designee will inspect the area for conformance to these specifications. Contractor shall rework areas that that are deemed not acceptable by the Construction Manager until acceptance is achieved.

3.8 MAINTENANCE

A. During work interruption(s) Contractor shall be solely responsible for preventing moisture loss from compacted materials.

B. Contractor shall remove and replace or recondition materials that have dried below the specified moisture range for that fill classification.

C. Contractor shall replace dried soils using material and procedures in accordance with these Specifications.

D. Temporary covers may be used to prevent moisture loss.

E. Desiccation Cracks

1. Desiccation cracks within the compacted material shall be repaired immediately by the Contractor.

2. Contractor shall repair shall desiccation cracks (less than 2 inches in depth) by discing or rotary tilling the fill to produce clods that are no greater than 2 inches. Moisture content of the fill shall be properly adjusted to within the range specified. Fill shall be thoroughly mixed to achieve a uniform moisture content distribution and compacted to the specified value.

3. Contractor shall repair deep desiccation cracks (greater than 2 inches in depth) by removing the fill from the compacted layer to a depth of 1.5 times the average depth of desiccation crack. Contractor shall replace and recompact fill into the excavated area meeting the requirements of the Specifications.

3.9 CONSTRUCTION TOLERANCE

A. Survey Precision

1. Contractor shall provide survey control for all earthwork placement, compaction, excavation and grading and as otherwise directed by the Construction Manager.

2. Contractor shall perform surveys of the work to ± 0.1 ft vertically and ± 0.25 ft horizontally.

B. Surface Tolerance

1. Contractor shall construct finished subgrades, compacted surfaces and drainage material layers from -0.0 to +0.1 ft.

2. Contractor shall provide constructed work with variations in final grade ≤ 0.25 ft above minimum thickness vertically between any two points located within 100 ft in any direction with the exception of designated changes in grade.

3.10 SURVEY CONTROL DATA

A. Survey data shall be collected as specified below or as otherwise directed by the Construction Manager.

B. Subgrade

1. Contractor shall collect survey data at points a maximum of 50 ft apart beneath the lining system footprint.
2. Contractor shall collect survey data at points 100 ft apart on the centerline of the perimeter berm.

3. Contractor shall collect survey data for the outside toe of the perimeter berm at the same frequency as the measurements of the centerline.

C. Perimeter Berm

1. Contractor shall collect survey data at points 100 ft apart. Survey data points shall at a minimum be on the centerline of the perimeter berm, the outside toe and the inside toe of the lift.

2. Contractor shall collect survey data on every third lift of the perimeter berm starting with the finished surface of the first lift.

D. Tracked In-place Fill

1. Contractor shall collect survey data at points 50 ft apart and no less than 6 points per grade.

2. Contractor shall collect survey data of the following surfaces:

- the finished layer to receive Tracked In-place Fill
- the compacted surface of the first lift of Tracked In-place Fill
- the final constructed surface of Tracked In-place Fill

E. Drainage Material

1. Contractor shall collect survey data at the following locations:

- the finished layer to receive the drainage material

- locations, widths, grades and elevations of gravel drains and sumps
- the top and bottom of each drainage layer

2. Contractor shall collect survey data at points no further than 25 ft apart and no less than 6 points per grade.

F. Protection Layer

1. Contractor shall collect survey data at points 100 ft apart and no less than 6 points per grade.

2. Contractor shall collect survey data on the finished surface to receive the Protection Layer and on the top of the Protection Layer.

G. Vegetated Cover

1. Contractor shall collect survey data at points 100 ft apart and no less than 6 points per grade.

2. Contractor shall collect survey data on the finished surface to receive the Vegetated Cover and on the top of the Vegetated Cover Layer.

3.11 QUALITY CONTROL

A. General

1. Tests and analysis of fill materials will be performed by the Contractor's approved QC personnel and Testing Laboratory.

2. Field inspection and testing will be performed by the Contractor.

3. The test frequency option which results in the greatest number of tests shall be used by the Contractor.

4. If the Construction Manager suspects the accuracy of the Nuclear Density gauge based on the review of QA test comparisons, the Contractor shall be responsible for proposing corrective actions to be taken to resolve discrepancies. The Construction Manager must approve the proposed corrective action before any further testing with the Nuclear Density gauge is accepted.

5. If the Contractor's in-place density test fails due to moisture content, re-test in the same area. If the second test fails, remove or rework area defined by surrounding tests meeting the Specifications.

6. All perforations due to density test probe, sample tubes, or test pit excavation shall be backfilled by the Contractor. All perforations shall be backfilled with material similar to that of the layer. Backfill shall be recompacted using methods and procedures specified. Contractor may use a powdered bentonite backfill as an option.

7. One point compaction tests shall be performed by the Contractor whenever a change in material is observed or suspected, as directed by the Construction Manager and no less than once per day per material type.

8. Contractor may use one point compaction data for calculation of maximum Standard Proctor dry density until a laboratory generated moisture density curve is developed. Contractor may continue placement at his own risk.

9. If placed and compacted material does not meet the requirements of these Specifications based on the laboratory generated moisture density curve, the Contractor shall remove or rework all such material to meet these requirements at no additional cost to the Owner.

10. Contractor shall submit all preconstruction and construction quality control data with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications have been achieved and the data as presented is representative of the material tested.

B. Preconstruction Material Quality Evaluation

1. The Contractor shall perform material quality evaluations on all proposed borrow sources for approval by the Construction Manager prior to procurement, excavating, transport, stockpiling or use.

2. Compacted Fill testing requirements:

• ASTM D 2216	1 per source
• ASTM D 4318	1 per source
• ASTM D 1140	1 per source
• ASTM D 698	1 per source

3. Tracked In-place Fill testing requirements:

• ASTM D 2216	1 per source
• ASTM D 4318	1 per source
• ASTM D 1140	1 per source
• ASTM D 698	1 per source

4. Drainage Material testing requirements for each sand and gravel source:

- ASTM D 2216 1 per source per type
- ASTM D 422 1 per source per type
- ASTM D 2434 1 per source per type

5. Protection Layer testing requirements:

- ASTM D 2216 1 per source
- ASTM D 4318 1 per source
- ASTM D 1140 or D 422 1 per source
- ASTM D 698 1 per source

6. Vegetated Cover Fill testing requirements:

- ASTM D 2216 1 per source
- ASTM D 4318 1 per source
- ASTM D 1140 1 per source
- ASTM D 698 1 per source
- ASTM D 5084 1 per source

C. Construction Material Quality Evaluation

1. Laboratory testing shall be performed by the Contractor's QC personnel on each source throughout the performance of construction.

2. Compacted Fill testing requirements for each borrow source used:

- ASTM D 2216 1 per 15,000 yds^3
- ASTM D 4318 1 per 15,000 yds^3
- ASTM D 1140 1 per 15,000 yds^3
- ASTM D 698 1 per 15,000 yds^3

3. Tracked In-place Fill testing requirements for each borrow source used:

- ASTM D 2216 1 per 5,000 yds^3
- ASTM D 4318 1 per 5,000 yds^3
- ASTM D 1140 1 per 5,000 yds^3
- ASTM D 698 1 per 10,000 yds^3

4. Drainage Material testing requirements for each sand and gravel source:

• ASTM D 2216	1 per 5,000 yds^3
• ASTM D 422	1 per 5,000 yds^3
• ASTM D 2434	1 per 5,000 yds^3

5. Protection Layer testing requirements for each material source:

• ASTM D 2216	1 per 5,000 yds^3
• ASTM D 1140 or D 422	1 per 5,000 yds^3
• ASTM D 698	1 per 5,000 yds^3

6. Vegetated Cover testing requirements for each material source:

• ASTM D 2216	1 per 10,000 yds^3
• ASTM D 4318	1 per 10,000 yds^3
• ASTM D 1140 or D 422	1 per 10,000 yds^3
• ASTM D 698	1 per 10,000 yds^3
• ASTM D 5084	1 per 10,000 yds^3

D. Post Constructed Quality Control

1. Compacted Fill

In-place density ASTM D2922 ASTM D3017	1 per 2,000 yd^3 placed and compacted
In-place density verification ASTM D2937 ASTM D2216	1 per 15,000 yd^3 placed and compacted

2. Tracked In-place Fill

In-place density ASTM D2922 ASTM D3017	1 per 10,000 ft^2 placed and compacted with a minimum of 6 per lift
In-place density verification ASTM D2937 ASTM D2216	1 per 2,000 yd^3 placed and compacted with a minimum of 1 per lift

END OF SECTION 02200

SECTION 02225

SEDIMENT MATERIAL HANDLING

SECTION 02225

SEDIMENT MATERIAL HANDLING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Excavation, temporary storage and transport of sediments, soils and subsurface soil materials.

B. Placement and compaction of excavated sediments, soils and subsurface soil materials in the Landfill.

C. All collection, control, temporary storage, testing and discharge of contaminated water associated with waste excavation, treatment, temporary storage, placement and compaction in the waste disposal cell.

D. Procurement, transportation, storage, handling, installation and operation of all equipment and materials necessary for conduct of the work.

E. Health and safety requirements of the project Health and Safety Plan, as well as Solutia's Pensacola Facility plant specific safety requirements.

1.2 DEFINITIONS

A. Sediments: Fine grained solids located within the limits of the Dead Creek remaining after the creek is unwatered and the residual material dewatered and dried.

B. Subsurface Soils: Existing soil material located directly beneath the sediments within the creek that require removal.

C. Contaminated Water: All stormwater falling directly on exposed sediments, stormwater run on contacting sediments or groundwater seepage contacting sediments material during excavation, temporary storage, handling, transport, placement or compaction.

D. Compactive Effort: Energy applied to the sediments or soils after placement in the Landfill by tracked or wheeled equipment.

1.3 SUBMITTALS

A. Excavation and Material Handling

1. Contractor shall submit an Excavation and Material Handling Plan for approval by the Construction Manager.

2. Contractor's Excavation and Material Handling Plan shall address excavation, stockpiling, temporary storage, handling, transport and placement into the Landfill for sediments and soils.

3. The Contractor's plan shall address management of contaminated water and shall be compatible with the water treatment system for this project.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. All equipment and tools used in the performance of this work are subject to the approval of the Construction Manager before work is started.

B. Provide compaction equipment appropriate for the material types to obtain the densities specified.

C. Provide hand-operated compaction equipment in areas closer than 2 feet (ft) from liners or structures to obtain the densities specified.

D. Operate and maintain compaction equipment in accordance with the manufacturer's instructions and recommendations. If inadequate densities are obtained, provide larger and/or different type equipment at no cost to the Owner.

E. Provide equipment for mixing and drying out material, such as blades, discs, or other approved equipment.

F. Contractor shall provide and operate dewatering equipment to remove and maintain control of stormwater runoff and keep the work area in an unwatered condition throughout the construction period in a manner approved by the Construction Manager.

PART 3 EXECUTION

3.1 GENERAL

A. All excavations, trenching, and shoring shall comply with the rules and regulations as established by OSHA Construction Safety and Health Regulations 29 CFR, Part 1926.

B. Contractor shall place all processed and temporarily stored sediments in such a manner as to prevent dispersal by wind, water erosion and to minimize the generation of leachate from rainfall.

C. Contaminated water within the confines of the active portion of the TSCA waste disposal cell, waste handling areas, and creek areas shall be controlled, collected, and discharged in accordance with the direction of the Construction Manager.

D. Mixtures of sediments with soils or subsurface soils shall be handled as if the mixture is 100 percent sediment for the purpose of placement and compaction.

3.2 SEDIMENT AND SOIL HANDLING

A. Dewatering/Drying

1. Sediments within the creek shall be dewatered and dried.

2. Contractor shall install dewatering sumps at the locations and in the manner selected by the Construction Manager.

3. Contractor shall maintain the dewatering sumps to promote removal of rainfall runoff and stormwater.

4. The Contractor may use mechanical methods such as discing, harrowing, or stockpiling to hasten the drying process as approved or as directed by the Construction Manager. The sediments shall not be placed into the landfill until dewatered sufficiently to pass the EPA paint filter criteria.

B. Sediment and Soil Excavation

1. Sediment and soils approved for placement in the Landfill shall be excavated, transported, placed and compacted by the Contractor in the manner approved by the Construction Manager.

2. Contractor shall excavate sediments in a coordinated fashion that minimizes the amount of handling and minimizes the potential to spill or generate contaminated water.

3. Subsurface soil materials located beneath the sediments shall be excavated by the Contractor as directed by the Construction Manager.

4. Excavated soils and subsurface soils shall be transported, placed and compacted in the disposal cell by the Contractor.

5. Contractor's Excavation and Material Handling Plan shall include methods and procedures to control and prevent stormwater run on and run off from areas with exposed sediments to adjacent areas.

3.3 PLACING AND SPREADING SEDIMENTS

A. Do not place sediments until the area to receive fill is completed and accepted by the Construction Manager.

B. Place sediment materials to the lines and grades shown on Plans with specified suitable materials.

C. Grade sediments in a manner that will promote positive site drainage and that will direct drainage away from the work and prevent ponding.

D. Uniformly grade areas to provide a finished surface that is smooth, compacted and free of irregularities. Comply with compaction requirements and grade to cross sections, lines and elevations indicated.

E. Place and compact the sediments in the landfill with sufficient compactive effort to provide a minimum undrained shear strength of 500 psf. Sediment shear strength will be measured by the Contractor and observed by the Construction CQA Consultant using either pocket penetrometer or field penetrometer instruments. The Construction Manager reserves the right to require a higher minimum shear strength if field conditions indicate that construction or operation problems will occur.

F. Place sediment adjacent to the side wall lining with a clearance between the construction equipment and lining of between 2 and 4 ft. The minimum undrained shear strength requirement shall not apply to sediments placed in this zone.

G. Compact each lift of fill thoroughly, using appropriate compaction equipment.

H. If tests indicate Work does not meet specified requirements, rework, remove or replace and retest at no cost to Owner.

I. Contractor shall minimize the surface area of placed sediments within the Landfill.

J. Exposed face of placed and compacted sludge shall vary in accordance with the thickness of the exposed fill.

K. Contractor shall place and compact sediment in accordance with the following:

Maximum Elevation Difference in Compacted Sediment Thickness (ft)	Maximum Exposed Sediment Face Slope Angle
5	3.0 (H) to 1 (V)
10	3.5 (H) to 1 (V)
15	4.0 (H) to 1 (V)

L. Contractor shall not place and compact sediment in layers that creates differences in surface elevations of greater than 10 ft.

3.4 PLACING AND SPREADING SOILS

A. Place soil materials to the lines and grades shown on Plans with specified suitable materials.

B. Grade soils in a manner that will promote positive site drainage and that will direct drainage away from the work and prevent ponding.

C. Uniformly grade areas to provide a finished surface that is smooth, compacted and free of irregularities. Comply with compaction requirements and grade to cross sections, lines and elevations indicated.

D. Place and compact the soils in the landfill with sufficient compactive effort to provide a minimum undrained shear strength of 500 psf. Shear strength will be measured by the Contractor and observed by the Construction CQA Consultant using either pocket penetrometer or field penetrometer instruments. The Construction Manager reserves the right to require a higher minimum shear strength if field conditions indicate that construction or operation problems will occur.

E. Place soils adjacent to the side wall lining with a clearance between the construction equipment and lining of between 2 and 4 ft. The minimum undrained shear strength requirement shall not apply to soils placed in this zone.

F. Compact each lift of fill thoroughly, using appropriate compaction equipment.

G. If tests indicate Work does not meet specified requirements, rework, remove or replace and retest at no cost to Owner.

H. Contractor shall minimize the surface area of placed soils within the Landfill.

I. Exposed face of placed and compacted soils shall vary in accordance with the thickness of the exposed fill.

J. Contractor shall place and compact soils in accordance with the following:

Maximum Elevation Difference in Compacted Soil Material Thickness (ft)	Maximum Exposed Soil Face Slope Angle
5	2.5 (H) to 1 (V)
10	3.0 (H) to 1 (V)
15	3.5 (H) to 1 (V)

K. Contractor shall not place and compact soil in layers that creates differences in surface elevations of greater than 10 ft.

END OF SECTION 02225

SECTION 02227

GEOGRID REINFORCEMENT

SECTION 02227

GEOGRID REINFORCEMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Geogrid reinforced ramp construction for landfill cell access.

1.2 REFERENCES

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A.	ASTM C136	Method for Sieve Analysis of Fine and Coarse Aggregates.
B.	ASTM D422	Method for Particle-Size Analysis of Soils.
C.	ASTM D698	Moisture Density Relations of Soils and Soil-Aggregate Mixtures Using a 5.5 Pound (2.49 kg) hammer and a 12-inch (304.8 mm) drop.
D.	ASTM D2487	Classification of Soils for Engineering Purposes.
E.	ASTM D2922	Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
F.	ASTM D3017	Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
G.	ASTM D4318	Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
H.	ASTM D4595	Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
I.	ASTM D5321	Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

1.3 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement, transport, stockpiling or use.

3. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

4. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

5. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted within 1 day of receipt.

6. Contractor shall submit signed documentation that the geogrid was installed in accordance with the Plans and Specifications.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the product.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of superintendent to be assigned to the project including dates/duration of employment. The superintendent shall have demonstrated experience of two similar projects.

2. A list of personnel to be performing field seaming operations with pertinent experience information.

3. All geosynthetic quality control certificates.

1.4 TESTING

A. Contractor shall retain the services of an independent testing laboratory. At a minimum, Contractor shall be responsible for providing the following quality control information:

1. Compliance testing for installed geosynthetics.

2. Quality control testing during construction.

B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

C. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

1.5 QUALITY ASSURANCE

A. Geogrid shall be free of defects, rips, holes, or flaws.

B. It shall be manufactured in widths and lengths that will permit installation with as few laps as possible.

C. Geogrid shall be marked with the Manufacturer's name, product identification, lot number, roll number, and roll dimensions.

D. Contractor shall provide a storage area such that geogrid is protected from mud, dirt, dust, debris, and exposure to ultraviolet (UV) light and heat.

E. Contractor shall submit all material and workmanship warranties for the geogrid installation.

1.6 DELIVERY, STORAGE AND HANDLING

A. Contractor shall check the geogrid upon delivery to assure that the proper material has been received.

B. Contractor shall maintain the integrity of the geogrids in a state equal to that which existed at the time of testing and certification for both onsite and offsite storage. This includes but is not limited to ultraviolet protection, protection against rodents, contaminant chemical abrasion, and any other harmful elements.

C. Geogrid shall be stored at temperatures above 35°F and be shaded from prolonged periods of direct exposure to sunlight.

D. Contractor shall prevent excessive mud, wet cement, epoxy, and like materials, which may affix themselves to the grid, from coming in contact with the geogrid material.

E. Rolled geogrid material shall be laid flat or placed on end for storage.

F. Only approved geogrids shall be used in construction. Geogrids delivered to the site shall be clearly marked to show the brand name, type of grid, ultimate tensile strength, location and date of manufacture, and its length (direction of reinforcement) and width.

G. Geogrids delivered to the project site shall remain in factory packaging capable of protecting it from sunlight (ultraviolet), moisture, or any other harmful elements until it is ready to be installed.

PART 2 PRODUCTS

2.1 DEFINITIONS

A. Fill: Selected soil materials to be used in construction of the geogrid reinforced ramp layer as specified in Section 02200.

B. Geogrid: An oriented high density polyethylene (HDPE) or polyester grid structure specifically manufactured for use as soil reinforcement.

C. Uniaxial Grid: A geogrid which has been manufactured with high tensile strength in one direction only.

D. Direction of Reinforcement: Refers to the orientation that the geogrid is used in for a particular project; along the roll for uniaxial geogrid.

E. MD: Machine direction.

F. CMD: Cross machine direction.

2.2 ACCEPTABLE MANUFACTURERS

A. The Tensar Corporation

B. A manufacturer of equivalent products, preapproved by the Construction Manager.

2.3 GEOGRID

A. The geogrid reinforcement shall be composed of either oriented high density polyethylene (HDPE); or high-tenacity polyester or polypropylene fibers coated with a protective coating of PVC, bitumen, or latex.

B. Contractor shall obtain from the manufacturer and shall furnish to the Construction Manager test reports certifying that the geogrid meets the requirements of this Specification prior to installation.

C. The geogrid reinforcement shall:

1. Be uniaxially or biaxially oriented polymer grid structure.

2. Be composed of polypropylene, polyester, or high density polyethylene.

D. The manufacturer shall submit test reports certifying that the product meets the requirements of this Specification.

E. The geogrid shall have the following minimum requirements:

Location	Long-Term Allowable Strength (lb/ft)	Minimum Ultimate Tensile Strength (lb/ft)
Ramp	N/A	7,000

F. Acceptable geogrid products are:

Location	Product Number	Manufacturer
Ramp	UX1600SB	Tensar
Ramp	UXP1500	Tensar
Ramp	UXP1600	Tensar

PART 3 EXECUTION

3.1 GEOGRID INSTALLATION

A. For landfill cell access ramps

1. After completion of the lining system installation in the ramp locations, place (2) 60-mil HDPE fly sheets directly over the clean lining surface and geonet, covering the entire slope length from crest to toe. The minimum width of the HDPE fly sheets shall be 20 feet (ft).

2. Place the geogrid over the HDPE layers, fully covering the slope length and extending outside the landfill cell the required distance. The minimum width of the geogrid ramp shall be 12 ft.

3. Bury the geogrid anchorage outside the landfill cell to the required length and depth.

4. Compact the geogrid anchorage backfill in 6 inch lifts to at least 95 percent of the maximum dry density determined by ASTM D698.

5. After all anchorage fill has been placed, place ramp fill on the landfill cell slope by dumping or pushing the fill down the prepared ramp area. Place at least 8 inches of fill before allowing equipment access.

6. The maximum gross vehicle weight for equipment constructing or using the ramp shall be 100,000 pounds.

B. All geogrid shall be placed at the proper location as shown on the Plans and at an orientation with its strongest axis within 5 degrees of being perpendicular to the slope direction. Correctness of the orientation (roll direction) of the geogrid shall be verified by the Contractor.

C. Adjacent geogrid panels shall be butted together and nylon cable ties shall be placed every 5 ft.

D. Geogrids shall be pulled taut in the reinforcement direction and secured in-place with sand bags, or backfill as required by fill properties, fill placement procedures or weather conditions, or as directed by the Contractor.

E. Geogrid may be connected to an identical geogrid panel using a Bodkin-type connection with components recommended by the geogrid manufacturer. The connection may not be located within 25 ft (in either direction) of the top of slope or slope break.

F. Backfill material shall be placed in lifts and compacted as directed under Section 02200 - Earthwork. Maintain ramp fill thickness as specified in Section 02200.

G. Backfill shall be placed, spread, and compacted in such a manner that minimizes the development of wrinkles in and/or movement of the geogrid.

H. Ramp fill material shall be placed, spread, and compacted in a manner that minimizes the development of wrinkles in and/or movement of the geogrid. Do not exceed 12 inches in loose lift thickness of ramp fill material.

I. Construction equipment shall not be operated directly on the geogrid. A minimum soil thickness of 6 inches is required prior to operation of tracked vehicles over the geogrid. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the soil and damaging the geogrid.

J. Rubber tired equipment may pass over geogrid reinforcement that has been covered with at least 12 inches of soil or ramp fill. Sudden braking and sharp turning shall be avoided.

K. Contractor shall take all necessary precautions to avoid damaging the geogrid during installation and soil placement. Geogrid damaged by the Contractor shall be repaired or replaced as directed by the Engineer at the Contractor's expense.

END OF SECTION 02227

SECTION 02242

GEOTEXTILE

SECTION 02242

GEOTEXTILE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Storage, handling, and installation of geotextile.

1.2 REFERENCES

A. ASTM D1117 - Methods of Testing Nonwoven Fabrics.

B. ASTM D5199 - Method for Measuring Thickness of Textile Materials.

C. ASTM D5261 - Test Method for Mass Per Unit Area (Weight) of Nonwoven Fabric.

D. ASTM D3786 - Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.

E. ASTM D4439 - Terminology for Geosynthetics.

F. ASTM D4491 - Test Methods for Water Permeability of Geotextiles by Permittivity.

G. ASTM D4533 - Test Method for Trapezoid Tearing Strength of Geotextiles.

H. ASTM D4632 - Test Methods for Breaking Load and Elongation of Geotextiles (Grab Method).

I. ASTM D4751 - Test Method for Determining Apparent Opening Size of a Geotextile.

J. ASTM D4833 - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

K. ASTM D4873 - Standard Guide for Identification, Storage and Handling of Geotextiles.

1.3 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement, transport, stockpiling or use.

3. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

4. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

5. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by an Illinois licensed surveyor shall be submitted within 1 day of receipt.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the product.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of superintendent to be assigned to the project including dates/duration of employment.

2. A list of personnel to be performing field seaming operations with pertinent experience information.

3. All geosynthetic quality control certificates.

D. Contractor shall submit all material and workmanship warranties for the geotextile installation.

1.4 TESTING

A. Contractor shall retain the services of an independent testing laboratory. At a minimum, Contractor shall be responsible for providing the following quality control information:

1. Compliance testing for installed geosynthetics.

2. Quality control testing during construction.

B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

C. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

PART 2 PRODUCTS

2.1 GENERAL

A. Contractor shall furnish materials whose "Minimum Average Roll Values" (MARV), as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria listed below.

B. Products shall be comprised of polymeric yarns of fibers oriented into a stable network which retains its relative structure during handling, placement and long-term service.

2.2 GEOTEXTILE

A. For filtration, cushion, separation and protection purposes, the geotextile shall consist of staple fiber needle-punched, nonwoven, polypropylene fabric where shown on the Drawings. The following minimum fabric properties are required:

GEOTEXTILE PROPERTIES			
Property	**Standard**	**MARV**	**Units**
Mass per Area	ASTM D 5261	16	oz/yd^2
Grab Strength	ASTM D 4632	380	lbs
Elongation	ASTM D 4632	60	%
AOS	ASTM D 4751	100	U.S. Sieve
Permittivity	ASTM D 4491	0.7	sec^{-1}
Trapezoidal Tear Strength	ASTM D 4533	145	lbs
Burst Strength	ASTM D 3786	750	psi
Puncture Strength	ASTM D 4833	240	lbs

2.3 MANUFACTURERS

A. Synthetic Industries

B. Approved Equal

PART 3 EXECUTION

3.1 INSTALLATION

A. Geotextile storage, handling and installation shall be the responsibility of the Contractor. Any damaged or unacceptable material shall be replaced at no additional cost to the Owner. During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls shall be shipped and stored in relatively opaque and watertight wrappings.

B. Geotextile rolls shall be handled in such a way that they are not damaged.

C. Geotextile shall be securely anchored and then rolled in such a manner as to continually keep the geotextile sheet in tension.

D. Geotextile shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

E. If white colored geotextile is used, precautions shall be taken against "snow blindness" of personnel.

F. Contractor shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.

G. Geotextile shall not be exposed to precipitation prior to being installed. Wrappings protecting geotextile rolls shall be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, the geotextile shall not be exposed to direct sunlight for more than 15 days (unless otherwise approved by the Construction Manager).

H. Contractor shall seam geotextile rolls by either overlapping, sewing or other methods approved by the Construction Manager.

I. At a minimum, the Contractor shall use the following seaming techniques at the specified locations:

Location	Method of Seaming
• Side Slopes of Lining System	Sewn
• Over Primary Collection System	Sewn
• Fabric Wrapped Around Sumps and Gravel Drain	Overlapped or sewn
• Beneath Tracked-in-Place Soil	Sewn
• Above Capillary Break Layer	Sewn
• Beneath Cover System Geomembrane	Overlapped or sewn
• Above Cover System Geomembrane	Sewn
• Slopes Steeper Than 10 Percent	Sewn
• Slopes Flatter Than 10 Percent	Overlapped or sewn

J. The geotextile seams not sewn shall be overlapped a minimum of 6 inches.

K. Geotextile seams designated as requiring to be sewn shall be continuously sewn with polymeric thread.

1. The thread shall be capable of supplying a seam strength efficiency of 80 percent of the required tensile strength utilizing a Type 401 two-thread chain stitch with a "J" seam.

2. The seam shall have 8 stitches per inch and the stitches shall be a minimum of 2 inches from the fabric edge.

L. Contractor shall pay particular attention at seams such that no soil material is inadvertently inserted beneath the geotextile.

M. Material placement shall be in the direction of the overlap.

N. Soil materials over the geotextile shall be placed in a manner such that the geotextile is not damaged, minimal slippage of the geotextile or underlying layers occurs, and no excess tensile stresses are present in the geotextile.

O. No construction equipment with ground pressure greater than 5 psi shall operate on slopes.

3.2 REPAIRS

A. Holes or tears in the fabric shall be repaired as follows: A fabric patch made from the same geotextile shall be placed over the hole or tear and sewn to the underlying geotextile. Provide a minimum overlap of 24 inches in all directions. Should any tear exceed 10 percent of the width of the roll, that section of the roll shall be removed and replaced.

3.3 QUALITY CONTROL

A. Visual inspections of shipment and storage activities shall be made by the Construction Manager to assure that the fabric has been protected from ultraviolet light exposure, precipitation or other inundation, and dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

B. Contractor shall designate each roll with a roll number (identification code) which is consistent with the layout plan. The rolls shall be positioned on the site as shown on the approved layout drawings. Instructions on boxes or wrapping containing the geotextile materials shall be followed to assure that rolls are unrolled in the proper direction.

3.4 MATERIAL QUALITY EVALUATION

A. Contractor shall submit an affidavit and/or quality control certificate signed by the manufacturer certifying that the geosynthetic rolls meet or exceed specified requirements to the Construction Manager for approval prior to deployment.

B. Preinstallation material quality evaluation testing shall be performed as follows:

• ASTM D5261	4 per roll
• ASTM D4632	1 per 50,000 ft^2
• ASTM D4751	1 per 50,000 ft^2
• ASTM D4491	1 per 50,000 ft^2
• ASTM D4533	1 per 50,000 ft^2
• ASTM D3786	1 per 100,000 ft^2
• ASTM D4833	1 per 100,000 ft^2

C. Conformance Testing

1. Samples shall be obtained at a frequency of one sample per 50,000 square feet.

2. The Contractor shall obtain samples and forward them to a laboratory designated by the Construction Manager.

3. Tests shall be performed to determine mass per Area (ASTM D5261), Permittivity (ASTM D4491), and Tensile Strength (ASTM D4632).

4. The sample shall be across the entire width of the roll excluding the first three (3) feet (ft), and shall be cut three (3) ft long by width roll.

5. Samples shall be 3 ft long by roll width. Machine direction shall be marked on sample with an arrow.

3.5 PLACEMENT OF EARTHEN MATERIALS OVER GEOTEXTILE

A. The Contractor shall place all earthen materials located on top of geotextile in such a manner as to ensure:

1. No damage of geotextile.

2. Minimal slippage of geotextile on underlying layers.

3. No excess tensile stresses in geotextile.

B. Place materials over geotextile by pushing material out over geotextile ahead of equipment in 12-inch thick minimum lifts.

C. On sideslopes, earthen material placement shall begin at toe of slope and proceed upslope to top of slope.

D. Equipment used to place earthen material over the geotextile shall have a maximum contact pressure of 5 lbs/sq inch on earthen material.

E. Thickness of earthen material over geotextile shall be 12 inches or more before equipment used to place earthen material shall be permitted to cross areas where geotextile has been installed.

F. Thickness of cover material over the top geotextile shall be 2 ft before vehicles with contact pressure greater than 8 lbs/sq inch shall be permitted to cross areas where geotextile has been installed.

END OF SECTION 02242

SECTION 02244

GEOMEMBRANE

SECTION 02244

GEOMEMBRANE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. The Contractor shall furnish all material, labor and equipment for the installation of the geomembrane as specified herein and as shown on the Drawings, and shall install the geomembrane and other geosynthetic components of the cover system in close coordination with the Construction Manager.

1.2 REFERENCES

A. ASTM D 638 - Test Method for Tensile Properties of Plastics.

B. ASTM D 792 - Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.

C. ASTM D 1004 - Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

D. ASTM D 1204 - Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.

E. ASTM D 1238, Condition E - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

F. ASTM D 1505 - Test Method for Density of Plastics by the Density - Gradient Technique.

G. ASTM D 1603 - Test Method for Carbon Black in Olefin Plastics.

H. ASTM D 1693 - Test Method for Environmental Stress-Cracking of Ethylene Plastics.

I. ASTM D 4339 - Terminology for Geosynthetics.

J. ASTM D 4437 - Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

K. ASTM D 4833 - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

L. ASTM D 4885 - Test Method for Determining Performance Strength of Geomembranes by Wide Strip Tensile Method

M. ASTM D 5199 - Test Method for Measuring Thickness of Plastics.

N. GRI GM 6 - Standard Practice for Pressurized Air Channel Test for Dual Seamed Geomembranes.

O. GRI GM 13 - Standard Specification for Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.

1.3 DEFINITIONS

A. Batch: A quantity of resin, usually the capacity of one railcar, used in the fabrication of High Density Polyethylene (HDPE) geomembrane rolls. The finished rolls are identified by a roll number corresponding to the resin batch used.

B. Bridging: Condition existing when the geomembrane is not in contact with the underlying material.

C. Contractor: The party responsible for manufacturing, shipping, field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installing the geomembrane. This responsibility includes the work performed by the Manufacturer and the Installer.

D. Manufacturer: The party responsible for production of any of the various geosynthetic components.

E. Installer: The part responsible for installation of the geosynthetics.

F. Extrudate: HDPE material produced in the form of a rod used by the Contractor to extrusion weld panels of geomembrane together.

G. Geomembrane: Very-low permeability synthetic flexible membrane liner (FML) barrier used to minimize fluid migration.

H. Geomembrane Subsurface: Material surface upon which geomembrane will be placed.

I. Quality Assurance Laboratory (Third Party Laboratory): Party, independent from the Owner, Manufacturer, and Contractor, responsible for conducting laboratory tests on samples of geomembrane obtained at the site.

J. Panel: The unit area of geomembrane, a roll or a portion of a roll, that will be seamed in the field.

K. Panel Layout Drawings: Drawings submitted by the Contractor indicating panel numbers, field seams, and details.

L. Subgrade: Soil material directly below the geomembrane.

1.4 TESTING

A. Contractor shall retain the services of an independent testing laboratory. At a minimum, Contractor shall be responsible for providing the following quality control information:

1. Compliance testing for installed geosynthetics.

2. Quality control testing during construction.

B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

C. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

1.5 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit the results of conformance testing of the geosynthetic materials selected for interface friction testing for approval within thirty (30) days of contract award.

3. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement transport, stockpiling or use.

4. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

5. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

6. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted written 1 day of receipt.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the products.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of Superintendent to be assigned to the project including dates/duration of employment.

2. Resume of Master Seamer including dates/duration of employment.

3. A list of personnel to be performing field seaming operations with pertinent experience information.

4. All geosynthetic quality control certificates .

5. Certification that the extrudate is comprised of the same resin as the geomembrane to be used.

6. Description of seaming techniques and apparatus to be used.

7. Properties of extrudate to be used.

D. Raw Materials

1. Copy of quality control certificates issued by resin suppliers.

2. Production date(s) of resin.

3. Reports on tests conducted to confirm quality of resin used to manufacture geomembrane rolls assigned to considered facility. Report shall indicate compliance with requirements in Part 2 – Products of this Specification.

4. Statement that no reclaimed polymer is added to resin during manufacture of actual geomembrane to be used in this project.

E. Geomembrane Roll Production: Copy of quality control certificates indicating compliance with requirements of Part 2 of this Specification.

F. Installation Panel Layout Drawing identifying placement patterns and seams, both fabricated (if applicable) and field seams, as well as any variance or additional details which deviate from the Drawings. Layout shall be drawn to scale and shall be adequate for use as the construction plan, and shall include information such as dimensions, panel numbering, and installation details. The Engineer shall review all Panel Layout Drawings prior to installation. Panel Layout Drawings, as prepared by the Contractor and reviewed by the Engineer, shall be submitted to USEPA 30 days prior to liner installation.

G. Installation Schedule.

H. During installation the Contractor shall submit:

1. Quality control documentation recorded during installation.

3. Daily subgrade acceptance for each area to be covered signed by the Installer.

I. Warranties:

1. Submit a material warranty signed by the geomembrane manufacturer. The material warranty shall be against manufacturing defects and workmanship, and against deterioration due to ozone, ultraviolet, and other exposure to the elements, for a period of one year from final acceptance. The material warranty shall be limited to replacement of material, and shall not cover installation of replacement geomembrane.

2. Submit workmanship warranty signed by the geomembrane installer. The installer shall warrant the geomembrane system to be installed to be free of defects in workmanship for a period of 2 years following the date of final acceptance of the work under this Contract. The workmanship warranty shall cover installation of replacement geomembrane.

J. Submittals Required for Project Closeout

1. Record Drawing: Submit reproducible drawings of record showing changes from the approved installation drawings. The record drawings shall include the identification and location of each repair, cap strip, penetration, boot, and sample taken from the installed geomembrane.

2. Quality Control Record: Submit copies of all material and seam test results. Each test shall be identified by date of sample, date of test, sample location, name of individual who performed the test, and standard test method used.

3. Weld Test Summary Report: Submit copies of report showing normal distribution of all test results, and individual test results identifying the high, low, and average of the five coupon samples in each test.

1.6 QUALIFICATIONS

A. Manufacturer

1. Manufacturer shall have at least 5 years continuous experience in the manufacturing of HDPE geomembrane rolls and experience totaling 2 million sq ft of manufactured HDPE for at least 10 completed facilities.

2. The Manufacturer shall have an internal quality control program that meets standard industry requirements.

B. Installer

1. The Installer shall have at least 5 years continuous experience in the installation of HDPE geomembrane and experience totaling 2 million sq ft of installed HDPE geomembrane for at least 10 completed facilities.

2. The Installer's Superintendent shall have previously managed at least two installation projects which entail at least 100,000 ft^2 of HDPE geomembrane.

3. Personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one "Master Seamer" shall have experience seaming a minimum of 1 million sq. ft. of HDPE geomembrane using same type of seaming apparatus in use on-site. The "Master Seamer" shall have experience seaming textured and non-textured material and shall provide direct supervision, as required, over less experienced seamers.

C. Quality Assurance Program

Manufacturer/Contractor shall agree to participate in and conform with all items and requirements of these Specifications and the Construction Quality Assurance Manual for the Installation of Geosynthetic Components.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver and store geomembrane in strict accordance with the manufacturer's recommendations.

B. Geomembrane delivered to the site shall be inspected for damage, unloaded, and stored with a minimum of handling. The storage area shall be such that materials are protected from mud, soil, dirt, and debris. Geomembrane may be stored directly on prepared level surface, but no more than three rolls in height.

C. The Contractor shall be responsible for coordination and payment of shipping, unloading, storing, handling and installing geomembrane.

D. Use appropriate handling equipment to load, move or deploy geomembrane rolls. Appropriate handling equipment includes slings, spreader bars or an equipment bucket which has been properly protected.

E. Damaged or unacceptable materials shall be replaced at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. GSE Lining Technology, Inc. (Gundle/SLT), Houston, Texas.

B. Approved Equal

2.2 GEOMEMBRANE

A. The geomembrane shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, as satisfactorily demonstrated by prior use.

B. The geomembrane shall be high-density polyethylene (HDPE) with a UV-stabilized surface and contain no plasticizers, fillers, chemical additives, reclaimed polymers, or extenders.

C. Approximately 2 percent carbon black shall be added to the resin for ultraviolet resistance.

D. The only other compound elements shall be anti-oxidants and heat stabilizers, of which up to 1.5 percent total, as required for manufacturing, may be added.

E. The geomembrane shall be supplied as a single-ply continuous sheet with no factory seams. Rolls shall have a minimum width of 22 feet.

F. The roll length shall be maximized to provide the largest manageable sheet for the fewest field seams.

G. All rolls shall be identified with a unique roll number printed on a label affixed to the inside and outside of the roll.

H. Each roll shall have a continuous identification printed on the membrane showing manufacturer, thickness, material, and date of manufacture.

I. HDPE geomembrane shall meet the following requirements:

HDPE GEOMEMBRANE - SMOOTH

Properties	Test Method	Requirements	Testing Frequency (minimum)
Liner Thickness, mils (nominal)	ASTM D5199	60	Per Roll
Density (g/cc)	ASTM D1505-A	0.94	200,00 lbs
Tensile Properties (min. aveg.) 1. Tensile Strength @ Yield (ppi) 2. Tensile Strength @ Break (ppi) 3. Elongation @ Yield (%) 4. Elongation @ Break (%)	ASTM D638 Type IV Dumb-bell @ 2 ipm (2.0" Gauge Length) (NSF 54, Mod.)	 126 228 12 700	20,000 lbs
Tear Resistance (min. aveg.)	ASTM D1004 Die C	42 lbs	45,000 lbs
Dimensional Stability % Change Each direction	ASTM D1204 212 °F 1 hr	± 2	
Stress Crack Resistance (hrs)	ASTM D5397	200	Per Batch
Puncture Resistance (min. aveg.)	ASTM 4833	108 lbs	45,000 lbs
Carbon Black Content (%) Carbon Black Dispersion	ASTM D1603 ASTM D5596	2 A1, A2 and B1	20,000 lbs 45,000 lbs
Oxidative Induction Time (OIT) (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.)	 ASTM D3895 ASTM D5885	 100 minutes 400 minutes	200,000 lbs

Properties	Test Method	Requirements	Testing Frequency (minimum)
Oven Aging at 85° (a) Standard OIT (min. aveg.) - % retained after 90 days -or- (b) High Pressure OIT (min. aveg.) - % retained after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	55% 80%	Per Batch
UV Resistance (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.) - % retained after 1600 hrs	GM 11 ASTM D3895 ASTM D5885	 Not Recommend 50%	Per Batch

HDPE GEOMEMBRANE - TEXTURED

Properties	Test Method	Requirements	Testing Frequency (minimum)
Liner Thickness, mils (nominal)	ASTM D5199	60	Per Roll
Density (g/cc)	ASTM D1505-A	0.94	200,00 lbs
Asperity Height (mils)	GM 12	10	Per Roll
Tensile Properties (min. aveg.) 1. Tensile Strength @ Yield (ppi) 2. Tensile Strength @ Break (ppi) 3. Elongation % Yield (%) 4. Elongation @ Break (%)	ASTM D638 Type IV Dumb-bell @ 2 ipm (2.0" Gauge Length) (NSF 54, Mod.)	 126 90 12 100	20,000 lbs
Tear Resistance (min. aveg.)	ASTM D1004 Die C	42 lbs	45,000 lbs
Low Temperature Brittleness °F	ASTM D746-B	-107 (max)	---
Dimensional Stability % Change Each direction	ASTM D1204 212 °F 1 hr	± 2	---
Stress Crack Resistance (hrs)	ASTM D5397	200	Per Batch
Puncture Resistance (min. aveg.)	ASTM 4833	90 lbs	45,000 lbs
Carbon Black Content (%) Carbon Black Dispersion	ASTM D1603 ASTM D5596	2 A1, A2 and B1	20,000 lbs 45,000 lbs
Oxidative Induction Time (OIT) (a) Standard OIT (min. aveg.) -or-	 ASTM D3895	 100 minutes	200,000 lbs

Properties	Test Method	Requirements	Testing Frequency (minimum)
(b) High Pressure OIT (min. aveg.)	ASTM D5885	400 minutes	
Oven Aging at 85° (a) Standard OIT (min. aveg.) - % retained after 90 days -or- (b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	--- 55% 80%	Per Batch
UV Resistance (a) Standard OIT (min. ave.) -or- (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs	GM 11 ASTM D3895 ASTM D5885	 Not Recommend 50%	Per Batch

J. Geomembrane shall not have striations, roughness, pinholes or bubbles on the surface

2.3 EXTRUDATE

A. Extrudate shall be made from the same resin as the geomembrane.

B. Additives shall be thoroughly dispersed in the extrudate.

C. Additives shall be free of contamination by moisture or foreign matter.

2.4 FIELD SEAMS

A. Approved processes for seaming are extrusion welding and fusion double seam welding. Fusion double seam welding is the preferred method for joining long, straight seams. Extrusion welding is the preferred seaming method in areas such as corners, sumps, pipe penetrations, tear repairs and cap strips where fusion double seam welding is not feasible.

B. Only apparatus which has been specifically approved by make and model shall be used.

C. Proposed alternate processes shall be documented and submitted by the Contractor for approval by the Construction Manager.

D. Resin used for extrusion welding shall be produced from same resin type as geomembrane.

E. Physical properties of the welding resin shall be the same as those of the resin used in the geomembrane.

F. Geomembrane seams shall meet following requirements:

HDPE GEOMEMBRANE SEAM PROPERTIES

Property	Qualifier	Unit	Specified Value	Test Method
Shear Strength (at yield point)	minimum	lb/in. width	120 and FTB[1]	ASTM D 4437
Peel Adhesion Fusion	minimum	lb/in. width	100 and FTB[1]	ASTM D 4437
Peel Adhesion Extrusion	minimum	lb/in. width	100 and FTB[1]	ASTM D 4437

Note:

[1] = Film Tear Bond (FTB) is defined as failure of one of the sheets by tearing, instead of separating from the other sheet at the weld interface area (i.e., sheet fails before the weld fails).

2.5 EQUIPMENT

A. Welding Equipment:

1. The Contractor shall provide welding equipment equipped with gauges showing temperatures at the nozzle (extrusion welder) or at the wedge (wedge welder), or have the equipment capable of measuring the temperature of the nozzle (hot air).

2. Equipment shall be maintained in adequate number to avoid delaying work, and shall be supplied by a power source capable of providing constant voltage under a combined-line load.

3. Electric generator shall not be placed on the membrane, unless otherwise approved by the Construction Manager.

B. Field Tensiometer:

1. The Contractor shall provide a tensiometer for onsite shear and peel testing of geomembrane seams.

2. The tensiometer shall be motor driven and have jaws capable of traveling at a measured rate of two (2) inches per minute.

3. The tensiometer shall be in good working order, built to ASTM specifications, and accompanied by evidence of recent calibration.

4. It shall be equipped with a gauge that measures the force in unit pounds exerted between the jaws and have a digital readout.

C. Punch Press:

1. The Contractor shall provide a punch press for the onsite preparation of specimens for testing.

2. The press shall be capable of cutting specimens in accordance with ASTM D4437.

D. Vacuum Box:

1. The Contractor shall provide a vacuum box for onsite testing of geomembrane seams.

2. The vacuum box shall have a transparent viewing window on top and a soft, closed-cell neoprene gasket attached to the bottom.

3. The housing shall be rigid and equipped with a bleed valve and vacuum gauge.

4. A separate vacuum source shall be connected to the vacuum box.

5. The equipment shall be capable of inducing and holding a vacuum of 5 psi.

E. Air Pressure Testing (for double seam with an enclosed space):

1. The equipment shall consist of a manual or motor driven air pump equipped with a pressure gauge.

2. The equipped shall be capable of generating and sustaining pressure over 25 psi.

3. Equipment shall be mounted on a cushion to protect the geomembrane.

4. It shall be equipped with a rubber hose with fittings and connections along with a sharp hollow needle.

5. Other pressure feed devices with a gauge and an accuracy of one (1) psi may be used, as approved by the Construction Manager.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

A. Contractor shall remove all gravel and other protrusions from geomembrane subgrade. Grade stakes or hubs shall also be removed from subgrade prior to geomembrane placement.

B. Special care must be taken to maintain prepared soil surface. Soil surface shall be observed daily to evaluate desiccation cracking. Damage to subgrade shall be repaired to the satisfaction of the Construction Manager.

C. Do not place geomembrane in area which has become softened by precipitation.

D. Contractor shall certify to the Construction Manager in writing daily that the surface on which the geomembrane will be placed is acceptable.

3.2 PREPARATIONS

A. Damage to geomembrane subsurface during geomembrane deployment or other activities shall be repaired prior to installation.

B. Subgrade shall be smooth and consist of clean fine graded material free of rocks, protrusions, sharp objects and deleterious material of any kind.

C. Edges of excavations and grade changes should be rounded to a minimum six (6) inch radius.

D. Geomembrane material may be placed when air temperature is greater than 35°F, and increasing or less than 100°F, unless other limits are approved, in writing, by the Construction Manager.

E. Do not place during precipitation in presence of excessive moisture (e.g., fog, dew), in area of ponded water, or during excessive winds.

3.3 ANCHOR TRENCH

A. The anchor trench shall be excavated by the Contractor to the lines and grades shown on the Plans prior to geomembrane deployment.

B. Contractor shall remove all loose soil from the anchor trench prior to geomembrane deployment No loose soil shall be allowed to underlie the geomembrane.

C. Excavated surface of the anchor trench shall be protected by the Contractor from desiccation or excessive moisture.

D. Contractor shall not damage geomembrane during backfill placement in anchor trench.

3.4 DEPLOYMENT

A. Each panel deployed shall be assigned a simple and logical identifying code consistent with the submitted panel layout drawings.

B. No more panels shall be deployed in one day that can be welded during that same day.

C. Tack welding may be acceptable as a temporary measure; however, tack welded panels shall not be left overnight.

D. Panels shall be shingled on all slopes such that the upper panel of a cross-seam is overlapped above the lower panel.

E. Panels shall be oriented perpendicular to the line of the slope crest (i.e., down and not across slope) anchored securely and deployed down the slope in a controlled manner. Panels shall not be pulled up the slope.

F. Ballast, that will not damage the geomembrane, shall be used to prevent uplift due to wind. Methods used shall minimize wrinkles.

G. Contractor shall securely anchor the geomembrane on a daily basis to prevent "pull-out" from the anchor trench with materials and methods approved by the Construction Manager. Special attention should be given to geomembrane shrinkage overnight.

H. Folds shall be immediately removed on all installations.

I. Personnel walking on the geomembrane shall not engage in activities or wear types of shoes, that could damage the geomembrane.

J. Smoking shall not be permitted while working on the geomembrane.

K. Vehicular traffic directly on the geomembrane shall not be permitted.

L. Equipment shall not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or any other means.

M. The geomembrane surface shall not be used as a work area, for preparing patches, storing tools and supplies, or other uses. If needed, a protective cover may be spread out as a work surface.

N. Material shall be placed in a manner to allow for geomembrane shrinkage, contraction and to avoid bridging.

3.5 SEAMING

A. Seam Layout

1. In general, orient end seams (traverse) parallel to line of maximum slope, i.e., oriented along, not across, slope. In corners and odd-shaped geometric locations, minimize numbers of field seams.

2. Seam coding system shall be compatible with panel coding system.

3. During welding operations, at least one Master Seamer shall be present and shall provide supervision over other welders.

4. The surface of the geomembrane shall be clean of grease, moisture, dust, dirt, debris, or other foreign material.

5. Solvents or adhesives shall not be used unless the product is approved in writing by the Construction Manager.

6. Panels shall overlap by a minimum of four (4) inches for all welds.

7. Seams shall be welded to the outside edge of panels placed under anchor berms or in anchor trenches.

8. Fishmouths or wrinkles at seam overlaps shall be cut to achieve a flat overlap.

9. The cut fishmouths or wrinkles shall be extrusion welded or patched where the overlap is more than three (3) inches.

10. When there is less than three (3) inches overlap, an oval or round patch extending a minimum of six (6) inches beyond the cut in each direction shall be used.

11. Seams shall be welded only when ambient temperature is between 35°F and 100°F as measured 6 inches above the geomembrane surface unless other limits are approved in writing by the Engineer.

B. Extrusion Seaming

1. Adjacent panels shall be tack bonded together using procedures that do not damage the geomembrane, allow required tests to be performed, and are not detrimental to final seaming.

2. Welding apparatus shall be free of heat-degraded extrudate before welding.

3. The geomembrane surface shall be abraded a maximum of 1/4 inch beyond the weld bead area, using a disc grinder, or equivalent, not more than one hour before extruding seam.

4. The ends of all seams, which are more than five (5) minutes old, shall be ground when restarting the weld.

5. Grinding depth shall not exceed ten (10) percent of the liner thickness.

6. Use apparatus equipped with gauges giving temperature in apparatus and at nozzle.

7. Provide documentation of extrudate to the Construction Manager and certify that extrudate is compatible with specifications and is comprised of same resins as geomembrane.

8. Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.

9. Purge extruder prior to beginning seam until all heat-degraded extrudate has been removed from barrel.

10. Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.

C. Fusion Seaming

1. Welding apparatus shall be automated, vehicular-mounted, and equipped with gauges indicating applicable temperatures and pressures.

2. Edges of cross seams shall be ground smooth including top and bottom prior to welding.

3. Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.

D. Trial Welds

1. Trial welds shall be performed on geomembrane samples to verify welding equipment operations and performance of seaming methods and conditions.

2. Minimum of two (2) trial welds per day or shift per welding apparatus shall be made, one made prior to the start of work and one completed at mid shift.

3. Welds shall be made under the same surface and environmental conditions as the production welds (i.e., in contact with geomembrane subsurface and similar ambient temperature).

E. Trial Weld Testing

1. Sample shall be at least three (3) feet long and two (2) feet wide with the seam centered lengthwise.

2. Three (3), 1-inch wide test strips shall be cut from the trial weld.

3. Each of the specimens shall be tested in the field by the Contractor for peel and shear using a digital tensiometer.

4. Remaining sample shall be retained for future testing.

5. A trial weld specimen shall pass when the results are achieved for both peel and shear tests as shown herein. For double-wedge welding, both welds shall be individually tested and both shall be required to pass in peel.

6. Seaming apparatus or seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and two consecutive successful full trial seams are achieved

3.6 MATERIAL QUALTY EVALUATION

A. Contractor shall submit an affidavit and/or quality control certificate signed by the geomembrane manufacturer certifying that the geomembrane blankets and/or rolls meet or exceed specified requirements to the Construction Manager for approval prior to geomembrane deployment.

B. Preinstallation material quality evaluation testing shall be performed as follows:

1. Raw material for geomembrane and extrudate rod or bead:

• ASTM D792	1 per batch
• ASTM D1238, Condition E	1 per batch
• ASTM D746	1 per batch

2. Geomembrane Roll:

• ASTM D5199	Continuous or 25 per sheet
• ASTM D638	1 per 50,000 ft^2
• ASTM D1505-A	1 per 50,000 ft^2
• ASTM D1004, Die C	1 per 50,000 ft^2
• ASTM D4833	1 per 50,000 ft^2
• ASTM D1603	1 per 100,000 ft^2

C. Conformance Testing

1. Samples shall be obtained at a frequency of one sample per 50,000 square feet.

2. The Contractor shall obtain samples and forward them to a laboratory designated by the Construction Manager.

3. Tests shall be performed to determine geomembrane Density (ASTM D1505), Thickness (ASTM D5199) and Tensile Strength (ASTM D 638).

4. The sample shall be across the entire width of the roll excluding the first three (3) feet, and shall be cut three (3) feet long by width of roll.

5. Within 30 days of contract award, Contractor shall submit the results of the following interface shear tests:

   - Smooth HDPE - Compacted Soil
   - Smooth HDPE - Geonet
   - Textured HDPE - Geonet
   - Textured HDPE - Geosynthetic Clay Liner

   These tests shall be performed in accordance with ASTM D 5321.

3.7 CONSTRUCTION QUALTY EVALUATION

A. Contractor shall non-destructively test all field seams over their full length using a vacuum test unit, air pressure (for double fusion seams only), or other approved methods. Non-destructive testing shall be carried out daily as the seaming progresses and not at completion of all seaming or at the completion of the day.

B. Vacuum testing shall conform to the following requirements:

1. The equipment shall consist of 2 vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, a soapy solution and an applicator.

2. Testing shall conform to the following procedure: Brush soapy solution on geomembrane (approximately 12" x 36"). Place vacuum box over the wetted seam area. Close bleed valve and open vacuum valve, and ensure that a leak-tight seal is created. Apply a vacuum of approximately five (5) psi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than fifteen (15) seconds. All areas where soap bubbles

appear shall be marked and repaired as described in this Section. If no bubble(s) appear after 15 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three (3) inches overlap, and repeat process.

C. Air Pressure Testing (for double seam with an enclosed space):

1. The equipment shall consist of an air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining pressure over twenty-five (25) psi and mounted on a cushion to protect the geomembrane, a rubber hose with fittings and connections, a sharp hollow needle, or other approved pressure feed device, and a gauge with an accuracy of one (1) psi.

2. Testing shall conform to the following procedure: Seal both ends of the seam to be tested. Insert needle or other approved pressure-feed device into the channel created by the double-wedge weld. Energize the air pump to a minimum pressure of twenty-five (25) psi, close the valve, and sustain the pressure for at least five (5) minutes. If pressure loss exceeds two (2) psi or does not stabilize, locate faulty area and repair as described in this Section. Puncture opposite end of the seam to release air. If blockage is present, locate and test seam on both sides of blockage. Remove needle or other approved pressure-feed device and seal penetration holes by extrusion welding.

D. Spark Testing: For those extrusion welded seams which are unable to be tested by a vacuum box, the spark test method shall be used with a 24-gauge copper wire placed 1/8" under the top sheet overlap and a Holiday detector operating at 20,000 volts.

E. Field seam locations that cannot be non-destructively tested by the Contractor as determined by the Construction Manager shall be cap-stripped using the same materials as the underlying geomembrane.

3.8 DESTRUCTIVE TESTING

A. Sample Location

1. Collect destructive test samples at a minimum frequency of one test per 500 feet of seam length. Test locations shall be determined during seaming. Locations may be prompted by appearance of excess heating, contamination, offset welds, or suspected defect. The Construction Manager shall be responsible for choosing the locations. The Construction Manager shall not notify the Contractor in advance of selecting locations where seam samples will be taken.

2. The Contractor shall cut samples at locations designated by the Construction Manager as the seaming progresses to obtain-laboratory test results before the geomembrane is covered. The Construction Manager shall number each sample and mark the sample number and location on the panel layout drawing.

3. The Contractor shall immediately repair all holes in the geomembrane resulting from destructive sampling. The continuity of the repair shall be vacuum tested in accordance with this Section.

4. The destructive sample shall be eighteen (18) inches wide by forty-two (42) inches long with the seam centered lengthwise. The sample shall be cut into three (3) equal parts for distribution to the Contractor, the Laboratory and the Owner for archiving.

B. Laboratory Testing

1. Samples shall be tested in peel and shear (ASTM D4437).

2. All tests shall exhibit a Film Tearing Bond type of separation in which the geomembrane material tears before the weld.

3. At least five (5) coupons shall be tested by each test method.

4. Four (4) of the five (5) coupons shall meet the minimum requirements stated herein.

5. Test results shall be provided verbally within 24 hours after receiving samples, and within three (3) days in written form.

C. Destructive Test Failure

1. One of two options shall be followed:

   a. <u>Option 1</u>: Reconstruct the seam between any two (2) passed test locations.

   b. <u>Option 2</u>: Trace the weld to an intermediate location at least ten (10) feet minimum or to where the seam ends, in both directions from the location of the failed test to collect a destructive test sample at both locations. Check the next seam welded using the same welding device if required to obtain an additional sample (i.e., if one side of the seam is less than ten (10) feet long). Bounding laboratory samples shall be taken, and destructive testing shall be performed per this Section. If the bounding samples pass, then the seam shall be reconstructed between the test sample locations. If any additional samples fail, then the process shall be repeated to establish the zone in which the seam shall be reconstructed.

2. Reconstruction methods shall include extrusion welding of previously wedge welded seams, cap stripping of seam, or replacing seam with a new one (1) foot wide panel and welding in place.

D. Acceptable seams shall be bounded by two locations from which samples have passed destructive tests. For reconstructed seams exceeding fifty (50) feet, a sample taken from within the reconstructed seam shall also pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were welded by the same welder and welding apparatus or were welded during the same shift.

3.9 DEFECTS AND REPAIRS

A. The geomembrane shall be examined for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

B. The geomembrane surface shall be clean at the time of the examination.

C. Each suspect location shall be repaired and non-destructively tested.

D. Geomembrane shall not be covered at locations which have been repaired until test results with passing values are available.

E. Damaged geomembrane shall be removed and replaced with acceptable geomembrane if damage cannot be satisfactorily repaired.

F. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test shall be repaired.

G. The Contractor shall be responsible for repair of damaged or defective areas. One of the procedures listed below shall be recommended by the Contractor and approved by the Engineer:

   1. Patching: Used to repair large and small holes, tears, undispersed raw materials, and contamination by foreign matter.

   2. Abrading and Re-welding: Used to repair small seam sections (less than twelve (12) inches long).

   3. Spot Welding: Spot welding is not allowed.

   4. Capping: Used to repair large lengths of failed seams.

   5. Removing unsatisfactory material and replacing with new material.

H. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.

   1. Patches or caps shall extend at least six (6) inches beyond the edge of the defect, and all corners of material to be patched and the patches shall be rounded to a radius of at least four (4) inches.

2. The geomembrane below large caps shall be cut to avoid water or gas collection between the two sheets.

I. Repairs shall be verified using the following procedure:

1. Each patch repair shall be non-destructively tested using methods specified in this Section.

2. Destructive testing may be required at the discretion of the Construction Manager.

3.10 GEOMEMBRANE ACCEPTANCE

A. Contractor shall retain all ownership and responsibility for the geomembrane until final acceptance by the Construction Manager.

B. Construction Manager will accept the geomembrane installation when the installation is finished and all required documentation from the Contractor has been received and approved, and verification of the adequacy of all field seams and repairs, including associated testing, is complete.

3.11 MATERIALS IN CONTACT WITH GEOMEMBRANE

A. General

1. Carefully install materials in contact with geomembrane surfaces to minimize damage potential.

2. Clamps, clips, bolts, nuts, or other fasteners used to secure geomembrane to each appurtenance shall have lifespan equal to or exceeding geomembrane's.

B. Pipes and Other Appurtenances

1. Install geomembrane around appurtenances, such as pipes, protruding through geomembrane as shown in Plans. Unless otherwise specified, initially install geomembrane sleeve or apron around each appurtenance prior to geomembrane installation.

2. After material is placed and seamed, complete final field seam connection between appurtenance sleeve or apron and geomembrane. Maintain sufficient initial overlap of appurtenance sleeve so shifts in location of geomembrane can be accommodated.

3. Extreme care shall be taken while seaming around appurtenances because both nondestructive and destructive seam testing might not be feasible. Do not damage geomembrane while making connections to appurtenances.

END OF SECTION 02244

SECTION 02245

GEOSYNTHETIC CLAY LINER

SECTION 02245

GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section includes the requirements for procurement, transportation, storage, handling, installation, and protection of geosynthetic clay liner (GCL).

1.2 REFERENCES

A. American Society for Testing Materials (ASTM)

1. ASTM E 496 - Test Method for Plate Water Absorption of Cohesive Soils.

2. ASTM D 4643 - Test Method for Determination of Water Content of Soil (modified)

3. ASTM D 5084 - Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter (modified).

4. ASTM D 5321 - Test Method for Determining the Coefficient of Soil an Geosynthetic or Geosynthetic Friction by the Direct Shear Method.

5. ASTM D 3776 - Test Method for Mass Per Unit Area of Textiles.

6. ASTM D 4632 - Test Method for Grab Breaking Load and Elongation of Geotextiles.

7. ASTM D 3786 - Test Method for the Mullen Burst Strength of Textiles.

B. U.S. Pharmacopoeia - National Formulary XVII, page 1210

1. USP-NF-XVII - Test Method for the Free Swell of Bentonite Clay.

C. Geosynthetics Research Institute, Drexel University

1. GRI-GCL-1 - Test Method for the Confined Swell of Geosynthetic Clay Liners.

1.3 SUBMITTALS

A. Pre-installation: Submit the following to the Engineer for approval prior to GCL deployment.

1. Manufacturer's specification for GCL which includes properties contained in Tables 1 and 2.

2. Written certification that the GCL meets the properties listed in Tables 1 and 2.

3. Written certification that GCL manufacturer has continuously inspected GCL for the presence of needles and found GCL to be needle-free.

4. Written certification from the GCL manufacturer that the bentonite will not shift during transportation or installation thereby causing thin spots in the body of the GCL.

5. Quality control certificates signed by a responsible entity of the GCL manufacturer. Each quality control certificate shall include roll identification numbers, and results of quality control tests. At a minimum, results shall be given for tests and corresponding methods specified in Tables 1 and 2.

6. Written certification that sealing material is made of same natural sodium bentonite as the GCL.

B. Installation: Submit the following as installation proceeds: Subgrade surface acceptance, signed by the Contractor for each area that will be covered directly by GCL.

1.4 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping

1. GCL shall be supplied in rolls wrapped individually in relatively impermeable and opaque protective covers.

2. GCL rolls shall be marked or tagged with the following information:

a. Manufacturer's name

b. Product identification

c. Roll number

d. Roll dimensions

e. Roll weight

B. Storage and Protection:

1. The Contractor shall provide on-site storage area for GCL rolls from time of delivery until installation. Rolls of GCL will be stored off the ground from time of delivery until they are installed.

2. After Contractor mobilization, store and protect GCL from dirt, water, ultraviolet light exposure, and other sources of damage.

3. Preserve integrity and readability of GCL roll labels.

PART 2 PRODUCTS

2.1 MATERIALS

A. The active ingredient of the GCL shall be natural sodium bentonite. The bentonite shall be encapsulated between two polypropylene textiles.

B. For side slopes steeper than 7H:1V the GCL shall be needle punched with high strength polypropylene thread to provide internal shear strength reinforcing. The internal shear reinforcing mechanism shall resist failure due to thread pull-out over long-term creep situations.

C. The textiles shall be sufficiently porous to allow bentonite flow-through such that the permeability of the overlap seams is equal to or less than the permeability of the body of the GCL sheet without the addition of granular or paste bentonite.

D. The non-reinforced GCL material shall have the following minimum properties:

TABLE 1

Test Designation	Test Method	Test Frequency	Report Value
Bentonite Swell Index	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss	ASTM D 5890	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area	ASTM D 5993	40,000 ft^2	0.75 lb/ft^2
GCL Grab Strength	ASTM D 4632	200,000 ft^2	75 lbs
GCL Peel Strength	ASTM D 4632	N/A	N/A
GCL Index Flux	ASTM D 5887	Weekly	$1x10^{-8}$ $m^3/m^2/sec$
GCL Permeability	ASTM D5084	Weekly	$5x10^{-9}$ cm/s
GCL Hydrated Internal Shear Strength	ASTM D 5321	Periodic	50 psf Typical

The reinforced GCL material shall have the following minimum properties:

TABLE 2

Material Property	Test Method	Test Frequency	Required Values
Bentonite Swell Index	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss	ASTM D 5890	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area	ASTM D 5993	40,000 ft^2	0.75 lb/ft^2
GCL Grab Strength	ASTM D 4632	200,000 ft^2	90 lbs
GCL Peel Strength	ASTM D 4632	40,000 ft^2	15
GCL Index Flux	ASTM D 5887	Weekly	$1x10^{-8}$ $m^3/m^2/sec$
GCL Permeability	ASTM D5084	Weekly	$5x10^{-9}$ cm/s
GCL Hydrated Internal Shear Strength	ASTM D 5321	Periodic	500 psf Typical

F. The bentonite shall be continuously adhered to both geotextiles to ensure that the bentonite will not be displaced during handling, transportation, storage and installation, including cutting, patching and fitting around penetrations.

G. The bentonite sealing compound or bentonite granules used to seal penetrations and make repairs shall be made of the same natural sodium bentonite as the GCL and shall be as recommended by the GCL manufacturer.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

A. The Construction Manager shall obtain certification from the Installer that the surface on which the GCL will be placed is acceptable. The Certificate of Acceptance shall be provided prior to GCL installation.

B. After the surface has been accepted by the Installer, it is the Installer's responsibility to indicate to the Construction Manager any change in surface condition that may require repair. If the Construction Manager concurs with the Installer, then the Earthwork Subcontractor shall be notified and the Construction Manager shall confirm that the surface is repaired.

C. The subgrade shall be maintained at the specified moisture content until covered by the GCL. Upon placement of panel(s), the Installer is responsible for maintaining/repairing the surface covered by the GCL unless otherwise agreed.

3.2 EXAMINATION

A. The Engineer will collect samples of GCL to be installed for conformance testing.

3.3 INSTALLATION

A. GCL Deployment: Handle GCL in a manner to ensure it is not damaged. At a minimum, comply with the following:

1. On slopes, anchor the GCL securely and deploy it down the slope in a controlled manner.
2. Weight the GCL with sandbags or equivalent in the presence of wind.
3. Cut GCL with a geotextile cutter (hook blade), scissors, or other approved device. Protect adjacent materials from potential damage due to cutting of GCL.
4. Prevent damage to underlying layers during placement of GCL.
5. During GCL deployment, do not entrap in or beneath GCL, stones, trash, or moisture that could damage GCL.
6. Visually examine entire GCL surface. Ensure no potentially harmful foreign objects such as needles are present.
7. Do not place GCL in the rain or at time of impending rain.

8. Do not place GCL in areas of ponded water.

9. Replace GCL that is hydrated before placement of overlying geomembrane.

10. In general, only deploy GCL that can be covered during that day by geomembrane or a minimum of twelve (12) inches of approved cover soil.

11. Orient the preferred GCL surface in relation to prepared soil or other geosynthetics as directed by the Representative.

12. On side slopes, run GCL to the bottom of the slope as indicated.

13. Seam areas or runs shall also be flat and clear of any large rocks, debris or ruts.

14. Contacting surfaces shall be clean and clear of dirt or native soil with all edges pulled tight to maximize contact and to smooth out any wrinkles or creases.

15. Overlaps shall be a minimum of six (6) inches.

16. A proper seam shall cover the six (6) inch lap line and leave the nine (9) inch match line exposed.

17. The Contractor shall only work on an area that can be completed in one working day.

18. Completion shall be defined as the full installation and anchoring of the liner and placement of the overlying specified geomembrane liner.

B. Overlaps:

1. On slopes, overlap GCL to the manufacturer's match line

2. In general, no horizontal seams are allowed on side slopes. Any horizontal seams on side slopes will be overlapped so that liquid will run from the top of the higher panel to the top of the lower panel. GCL shall not be placed so that liquid from a higher panel can run underneath a lower panel.

3. Apply granular bentonite to overlapped area at a rate of 1/4 pound per linear foot.

4. At sumps, overlap GCLs at least one (1) foot.

5. At bottom of collection sumps, unroll an extra layer of GCL on top of previously installed GCL. Avoid placing seams on top of underlying seams.

6. Seams shall be augmented with granular bentonite to ensure seam integrity.

7. Granular bentonite shall be dispersed evenly from the panel edge to the lap line at a minimum rate of ¼ pound per linear foot continuously along all seams or overlap areas.

8. Accessory bentonite shall be of the same type as the material within the composite liner itself. Adhesives may be used on seams to keep panels in contact during backfill operations, if necessary.

C. Defects and Repairs:

1. Repair all flawed or damaged areas by placing a patch of the same material extending at least one (1) foot beyond the flaw or damaged area.

2. Treat seams of repaired areas as per stated in Overlaps above.
3. The edges of the patch shall be fastened to the repaired liner with construction adhesive, in addition to the bentonite-enhanced seam.

D. Interface with Other Products: Ensure the following when deploying overlying material.

1. GCL and underlying materials are not damaged.

2. Minimal slippage of GCL on underlying layers occurs.

3. No excess tensile stresses occur in GCL.

3.4 ANCHOR TRENCH SYSTEMS

A. Anchor trenches shall be excavated to the lines and grades shown on the Drawings prior to placement of the GCL.

B. To minimize desiccation of the clay, no more than the amount of trench required for the GCL to be anchored in one day shall be excavated.

C. The corners of the anchor trench where the GCL enters the trench shall be rounded to a smooth radius prior to the installation of the GCL.

D. No loose soil shall be allowed to underlie the GCL in the anchor trench.

E. The GCL shall be temporarily anchored with sand bags or other approved means until the overlying geosynthetics are placed and secured.

3.5 EQUIPMENT

A. Storage

1. Wooden pallets for above ground storage of GCL.

2. Heavy, waterproof tarpaulin for protecting unused GCL.

B. Installation

1. Equipment used for GCL deployment shall utilize a spreader bar to prevent slings from damaging edges.

2. Steel pipe shall be inserted into roll core for lifting.

3. Sand bags for securing tarpaulin.

4. 3-inch wide grips for moving GCL panels into place for each installation technician.

5. Bentonite Sealing Compound and/or Granular Bentonite for securing around penetrations and structures.

6. Equipment used for the placement of all liners above the GCL shall not exceed a ground pressure of four (4) psi.

3.6 CONFORMANCE TESTING

A. Within 30 days of award, Contractor shall submit the results of the following interface friction tests:

- Compacted Soil - Geosynthetic Clay Liner ASTM D 5321
- Textured HDPE - Geosynthetic Clay Liner ASTM D 5321

END OF SECTION 02245

SECTION 02246

GEONET

SECTION 02246

GEONET

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section includes the requirements for geonet procurement, transportation, storage, handling and installation.

1.2 REFERENCES

A. ASTM D413 - Standard Test Methods for Rubber Property – Adhesion to Flexible Substrate.

B. ASTM D792 - Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.

C. ASTM D1238 - Condition E Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

D. ASTM D1505 - Test Method for Density of Plastics by the Density – Gradient Technique.

E. ASTM D1603 - Test Method for Carbon Black in Olefin Plastics.

F. ASTM D4439 - Terminology for Geosynthetics.

G. ASTM D4716 - Standard Test Method for Constant Head Hydraulic Transmissivity (In-plane Flow) of Geotextiles and Geotextile Related Products.

H. ASTM D4595 - Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method.

I. ASTM D5199 - Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

1.3 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement, transport, stockpiling or use.

3. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

4. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

5. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted within 1 day of receipt.

6. Contractor shall submit signed documentation that the geonet was installed in accordance with the Plans and Specifications.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the product.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of superintendent to be assigned to the project including dates/duration of employment. The superintendent shall have demonstrated experience of two similar projects.

2. A list of personnel to be performing field seaming operations with pertinent experience information.

3. All geosynthetic quality control certificates.

1.4 TESTING

A. Contractor shall retain the services of an independent testing laboratory. At a minimum. Contractor shall be responsible for providing the following quality control information:

1. Compliance testing for installed geosynthetics.

2. Quality control testing during construction.

B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

C. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

1.5 QUALITY ASSURANCE

A. Geonet shall be free of defects, rips, holes, or flaws.

B. It shall be manufactured in widths and lengths that will permit installation of geonet with as few laps as possible.

C. Geonet shall be marked with the Manufacturer's name, product identification, lot number, roll number, and roll dimensions.

D. Contractor shall provide a storage area such that geonet is protected from mud, dirt, dust, debris, and exposure to ultraviolet (UV) light and heat.

E. Contractor shall submit all material and workmanship warranties for the geonet installation.

1.6 GEONET TRANSPORTATION, HANDLING, AND STORAGE

A. Transportation of geonet is responsibility of Contractor, who shall be liable for all damages to geonet prior to and during transportation to Site.

B. Handling, storage, and care of geonet on-site is responsibility of Contractor prior to, during and after geonet installation.

C. Contractor shall retain ownership of geonet until installation is accepted by the Construction Manager. Contractor shall be liable for all damages to geonet incurred prior to final acceptance of installation by Construction Manager.

PART 2 PRODUCTS

2.1 GEONET

A. Provide products for the geonet comprised of high-density polyethylene (HDPE). The geonet shall be manufactured by extruding two sets of strands to form a three dimensional structure to provide plane flow and shall meet the following minimum average roll values except as noted.

GEONET PROPERTIES			
Property	**Test**	**Value**	**Units**
Density	ASTM D792 or D1505	0.90 min.	g/cu cm
Thickness	ASTM D5199	200 min.	mils
Melt Flow Index	ASTM D1238	1.0 max.	g/10 min.
Carbon Black Content	ASTM D1603	2-3 range	%
Tensile Strength at Break: • Machine Direction • Cross Direction	 ASTM D4595 ASTM D4595	 360 (min.) 200 (min.)	 lbs/ft lbs/ft
Transmissivity	ASTM D4716	1.0	cm/sec

PART 3 EXECUTION

3.1 GEONET PLACEMENT AND HANDLING

A. Handle all geonet in such a manner as to ensure it is not damaged in any way. Damaged geonet shall not be installed. If geonet is damaged during or after installation, it shall be replaced.

B. Geonet shall be anchored and installed by rolling it down the slope so as to continually keep the material in tension.

C. In the presence of wind, geonets shall be weighted with sandbags or equivalent. Such sandbags shall be installed during placement and shall remain until replaced with earthen cover material.

D. Geonets shall be cut using an approved cutter only. If in place, special care must be taken to protect geomembrane from damage which could be caused by cutting of geonets.

E. During placement, care shall be taken not to entrap in geonet stones, excessive dust, or moisture that could hamper subsequent seaming. If geonet is not free of debris and soil prior to installation, Contractor shall clean geonet prior to installation.

F. The Contractor shall examine the geonet over the entire surface, after installation, to ensure that no potentially harmful foreign objects are present. Any foreign objects so encountered shall be removed by Contractor, or geonet shall be replaced.

G. Geonet shall not be welded or tack welded to the underlying geomembrane.

3.2 QUALITY CONTROL

A. Visual inspections of shipment and storage activities shall be made by the Construction Manager to assure that the geonet has been protected from ultraviolet light exposure, precipitation or other inundation, and dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

B. Contractor shall designate each roll with a roll number (identification code) which is consistent with the layout plan. The rolls shall be positioned on the site as shown on the approved layout drawings. Instructions on boxes or wrapping containing the geotextile materials shall be followed to assure that rolls are unrolled in the proper direction.

3.3 MATERIAL QUALITY EVALUATION

A. Contractor shall submit an affidavit and/or quality control certificate signed by the manufacturer certifying that the geosynthetic rolls meet or exceed specified requirements to the Construction Manager for approval prior to deployment.

B. Preinstallation material quality evaluation testing shall be performed as follows:

• ASTM D5199	4 per roll
• ASTM D792 or D1505	1 per batch
• ASTM D4595	1 per 40,000 ft^2
• ASTM D1238	1 per batch
• ASTM D1603	1 per batch

C. Conformance Testing

1. Samples shall be obtained at a frequency of one sample per 50,000 square feet.

2. The Contractor shall obtain samples and forward them to a laboratory designated by the Construction Manager.

3. Tests shall be performed to determine Density (ASTM D792), Thickness (ASTM D5199) and Tensile Strength (ASTM D751) and Transmissivity (ASTM D4716).

4. The sample shall be across the entire width of the roll excluding the first three (3) feet, and shall be cut three (3) feet long by width roll.

5. Samples shall be 3 feet long by roll width. Machine direction shall be marked on sample with an arrow.

3.4 GEONET SEAMS AND OVERLAPS

A. The geonet shall be overlapped at least 4 inches on downslope seams and joined by colored plastic ties every 5 feet.

B. On transverse (horizontal) seams the geonet shall be overlapped 12 inches and joined by colored plastic ties every 12 inches. No horizontal seams will be allowed on slopes greater than 6:1.

C. Metallic devices are not allowed.

D. Seams shall be tied continuously through the anchor trenches and toe drains every 12 inches.

E. Unless prior approval is obtained, no horizontal seams shall be allowed on side slopes.

F. In the event horizontal seams on side slopes can not be avoided, adjacent rolls shall be tied every 6 inches.

3.5 GEONET REPAIR

A. Any holes or tears in geonet shall be repaired as follows: A patch made from same geonet material shall overlap the undamaged geonet a minimum of 12 inches on all sides and tied every 6 inches.

END OF SECTION 02246

SECTION 02619

CORRUGATED POLYETHYLENE PIPE

SECTION 02619

CORRUGATED POLYETHYLENE PIPE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section includes the requirements for procurement, transportation, storage, handling and installation of corrugated polyethylene pipe and filter fabric as a drainage conduit for the cover system.

1.2 REFERENCES

A. ASTM D618 - Practice for Conditioning Plastics and Electrical Insulating Materials for Testing.

B. ASTM D1248 - Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.

C. ASTM D2122 - Determining Dimensions of Thermoplastic Pipe and Fittings.

D. ASTM F405 - Standard Specification for Corrugated Polyethylene (PE) Tubing and Fittings.

1.3 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement, transport, stockpiling or use.

3. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

4. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

5. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted within 1 day of receipt.

6. Submit list of minimum property values for the pipe, fittings and filter fabric including certified test results to the Construction Manager. Material properties shall be in conformance with those defined herein.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the product.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of superintendent to be assigned to the project including dates/duration of employment.

2. A list of personnel to be performing field seaming operations with pertinent experience information.

3. All geosynthetic quality control certificates.

1.4 QUALITY ASSURANCE

A. Filter fabric shall be free of defects, rips, holes, or flaws.

B. During shipment and storage, the pipe shall be wrapped in relatively impermeable and opaque protective covers.

C. Pipe shall be marked with the manufacturer's name, product identification, lot number, roll number, and roll dimensions.

D. Storage area shall be such that filter fabric is protected from mud, dirt, dust, debris, moisture, and exposure to ultraviolet (UV) light and heat.

E. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

F. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

G. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

H. Contractor shall submit all material and workmanship warranties for installation of the pipe.

1.5 TRANSPORTATION, HANDLING AND STORAGE

A. Transportation is the responsibility of the Contractor, who shall be liable for all damages prior to and during transportation to site.

B. Handling, storage, and care on-site is responsibility of the Contractor prior to, during and after installation. The Owner will designate adequate storage space on-site. Contractor shall be liable for all damages incurred prior to final acceptance, except for those due to negligent actions on part of the Owner.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Hancor, Inc. - Hancor Heavy Duty Tubing with Highway Sleeve

B. Advanced Drainage Systems, Inc. - ADS Single Wall with ADS Sock

C. Approved Equal

2.2 PIPE

A. The drainage piping (pipe and fittings) shall be four (4) inch perforated, corrugated, high density polyethylene (HDPE) piping (i.e., tubing) meeting or exceeding the criteria below.

Inside Diameter (in.)	4.0
Outside Diameter (in.)	4.6 nominal
Pitch (in.)	0.7
Corrugations	Annular
Perforations	Slotted (6 per circumference)
Inlet Area (sq in./ft) • Minimum • Maximum	 2.4 3.8

B. The drain outlets shall meet the above requirements, except perforations (i.e., slots) are not allowed.

2.3 FILTER FABRIC

A. The filter fabric shall meet the following minimum values:

Size (in.)	4
Fiber	Knitted Polyester
Specific Gravity	1.3
Yarn Denier	150-200
Weight (oz/yd^2 relaxed)	5.4
Weight (oz/yd^2 applied)	3.5
Cross Stretch (in.)	14.5
Melt Point ((^{o}F)	450-500
Thickness (in.)	0.04
Mullen Burst (psi)	100-135
Water Permeability (K) @ 3 gpm	0.12
EOS. U.S. Sieve	40

B. The filter fabric shall be applied to the pipe by the manufacturer prior to shipment.

PART 3 EXECUTION

3.1 PLACEMENT AND HANDLING

A. Handle all materials in such a manner as to ensure it is not damaged in any way.

B. Materials shall not be dragged.

C. During placement, care shall be taken not to entrap stones, excessive dust, or moisture that could hamper subsequent performance. If pipe is not free of debris and soil prior to installation, Contractor shall clean material prior to installation.

D. The Construction Manager will examine the drainage piping over the entire surface to ensure that no potentially harmful foreign objects are present. Any foreign objects so encountered shall be removed by the Contractor, or material shall be replaced.

3.2 INSTALLATION

A. Installation shall be in accordance with manufacture's instructions.

B. Pipe shall be joined with internal or external couplers, or coupling bands and fittings supplied by the pipe manufacturer covering at least two (2) full corrugations on each of the pipe ends.

C. The filter fabric shall be completely continuous along the perforated pipe.

D. Filter fabric joints must have a minimum overlap of six (6) inches.

E. The filter fabric shall be secured to the pipe in such a manner that sand bedding shall not infiltrate through any overlaps.

F. Seal filter fabric at all outlet drain locations such that no water will enter perforations unless passing through the filter fabric.

G. Contractor shall ensure that the outlet drains have been inspected and approved by the Construction Manager prior to backfill.

H. Contractor shall protect the ends of the drain pipes from being damaged or from allowing foreign objects(e.g., debris, sand, filter fabric) from entering the pipes.

I. Each pipe shall be inspected by the Contractor prior to making connections to ensure pipe is free of foreign objects. Any foreign objects shall be removed by the Contractor.

J. Contractor shall exercise care to thoroughly compact the sand under the haunches of the pipe and to ensure that the material is in intimate contact with the pipe. The backfill shall be brought up evenly in layers on both sides of the pipe until the trench is fill to the required elevation.

K. Contractor shall replace or repair any damaged pipe or filter fabric as directed by the Construction Manager, at no additional cost the Owner.

L. The Contractor is responsible for all excavation and backfill required for complete installation of toe drain outlets.

M. The drain outlets shall be installed on 150 foot centers, as shown on the Plans.

END OF SECTION 02619

SECTION 02715

LEACHATE COLLECTION SYSTEM RISER PIPES

SECTION 02715

LEACHATE COLLECTION SYSTEM RISER PIPES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Primary and secondary leachate collection system riser pipes.

1.2 REFERENCES

A. ASTM D1505 - Density of Plastics

B. ASTM D751 - Standard Test Method for Coated Fabrics

C. ASTM D638 - Standard Test Method for Tensile Properties of Plastics

1.3 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer and Installer.

2. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement, transport, stockpiling or use.

3. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

4. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

5. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data. field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted within 1 day of receipt.

6. Contractor shall submit HDPE pipe pressure test procedures in writing for Construction Manager approval.

B. Manufacturer

1. The Manufacturer shall submit the following prior to installing leachate collection system riser pipes:

   - A list of material properties including certified test results attached to samples of the proposed HDPE riser pipes.

   - The origin and identification of the resin used to manufacture the product.

   - Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

1. The Installer shall submit the following prior to installation:

   - Resume of superintendent to be assigned to the project including dates/duration of employment.

   - A list of personnel to be performing installation operations with pertinent experience information.

   - All HDPE pipe quality control certificates.

1.4 TESTING

A. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

B. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

C. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

PART 2 PRODUCTS

2.1 GEOPIPE

A. Leachate collection system pipe shall conform to the following minimum material specifications for HDPE Pipe:

Property	ASTM Reference	Nominal Value	Unit
Density (pipe)	D1505	0.955	g/cm^3
Density (natural base resin)	D1505	0.945	g/cm^3
Melt Index, condition E	D1238	0.1-0.2	g/10 min.
Melting Point (Vicat Softening Temperature)	D1525	255	°F
Brittleness Temperature	D746	<-180	°F
Thermal Expansion	D696	$9X10^{-5}$	in/in/°F
Thermal Conductivity	C177	2.7	$Btu\text{-}in/ft^2/hr/°F$
Tensile Strength, yield (2.0 in/min.)	D638	>3200	psi
Tensile Strength, ultimate (2.0 in/min.)	D638	≥5000	psi
Elongation (2.0 in/min.)	D638	≥800	percent
Modulus of Elasticity	D638	110,000	psi
Flexural Modulus	D3350	125,000	psi
Long Term Hydrostatic Strength (LTHS)	D2837	1600	psi
Hydrostatic Design Basis (HDB)	D2837	1600	psi
Hardness - Shore D	D2240	66	--
Environmental Stress Crack Resistance (ESCR), condition C	D1693	>5000	hrs.

B. HDPE Pipe shall meet the following minimum requirements:

Specified Size (in.)	Min ID (in.)	Max SDR[1]
6	5.5	11
8	7.5	26
12	11.1	26

[1] SDR = Standard Dimension Ratio = Pipe OD/Pipe Thickness.

C. Slotted PE pipe shall have 1/16-inch wide slots on 1/4-inch centers or approved alternate.

D. Contractor shall perforate one end of the HDPE pipe for a length of 3 feet. Adjacent rows of the perforations shall be offset by one-half the distance between perforations in any row.

PART 3 EXECUTION

3.1 PREPARATION

A. Verify all lines and grades of field conditions are as shown on the Plans.

B. Verify that all surfaces have been properly prepared prior to installation of the leachate collection or detection systems.

3.2 INSTALLING LEACHATE COLLECTION AND DETECTION SYSTEM RISER PIPES

A. General

1. The leachate collection system riser shall be installed and constructed in accordance with the lines, grades, dimensions, and cross sections shown on the Plans and as required by these Specifications.

B. Excavating Riser Pipe Trench

1. The riser pipe trench shall be excavated along the slope of the excavation to the grades, dimensions, cross-sections, and details shown on the Plans or as directed by the Construction Manger.

2. Excavate utilizing suitable equipment in a manner approved by the Construction Manager.

3. Contractor shall not damage installed geosynthetics during excavation.

C. Installing Riser Pipe

1. The HDPE riser pipe (casing) shall be installed to the design lengths indicated on the Plans in a work area to be designated by the Construction Manager.

2. HDPE pipe shall be welded to construct the length specified on the Plans prior to placement on the slope. Contractor shall join pipe segments using butt fusion welding techniques.

3. Positive anchorage of the riser pipe to prevent pipe movement during backfilling is required.

4. The HDPE riser pipe shall be slotted in accordance with the dimensions required by these specifications and in accordance with manufacturer recommendations. Slotted portion of pipe shall be installed into and shall not exceed thickness of the collection sump. Remainder of pipe length shall not be slotted.

5. The HDPE riser pipe shall be placed against the prepared surface of the slope excavation by the Contractor using suitable equipment in a manner approved by the Construction Manager and in accordance with the manufacturer recommendations. The HDPE riser pipe shall be anchored at the top with ballast approved by the Construction Manager.

6. Synthetic membranes shall be constructed around the riser pipe as shown in the Plans and in accordance with the requirements of these Specifications.

D. Placing Riser Pipe Backfill

1. Bedding material may be utilized on the prepared surface beneath the HDPE riser pipe to facilitate pipe placement as well as the placement and compaction of the backfill materials.

2. Soil designated "Compacted Fill" shall be used as backfill around the pipe. Contractor shall roll fill into place without damaging the underlying geosynthetics.

3. Backfill soil shall be compacted by the Contractor using tracked equipment having ground pressure ≤ 5 psi. Backfill soil shall have no less than 2 coverages with the equipment.

4. Contractor shall use proper care not to damage underlying geosynthetics during soil placement or compaction. Equipment shall not make quick starts, stops or turns which may damage geosynthetic materials.

5. Backfill placement shall begin at the toe of slope and proceed upslope.

6. Backfill placed and compacted to thicknesses or grades in excess of the grades on either side of the riser pipe trench shall be trimmed by approved measures to conform to the surrounding grades.

3.3 MATERIAL QUALITY EVALUATION

A. Contractor shall submit an affidavit and/or quality control certificate signed by the manufacturer certifying that the HDPE pipe will meet or exceed specified requirements to the Construction Manager for approval prior to deployment.

B. Preinstallation material quality evaluation testing shall be performed as follows:

• ASTM D1505	1 per batch
• ASTM D638	1 per 1,000 ft of pipe
• ASTM D2837	1 per 1,000 ft of pipe
• ASTM D2240	1 per 1,000 ft of pipe

3.4 FIELD QUALITY CONTROL

A. HDPE Pipe

1. Visually inspect all HDPE pipe couplings and welds.

2. Pressure test sump discharge conduit to 30 psi.

END OF SECTION 02715

SECTION 02932

SEEDING

SECTION 02932

SEEDING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Provide all labor, material, equipment and incidentals required to seed, fertilize, mulch and maintain the vegetated cover.

1.2 REFERENCES

A. FS 0-F-241 - Fertilizers, Mixed Commercial

1.3 DEFINITIONS

A. Weeds: Includes Dandelion, Jimsonweek, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweek, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, And Brome Grass.

1.4 REGULATORY REQUIREMENTS

A. Contractor shall comply with regulatory agency requirements for fertilizer and herbicide composition.

B. Contractor shall provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

C. Contractors shall submit maintenance requirements for continuing maintenance of established vegetated cover.

D. Contractor shall include maintenance instructions, cutting method and maximum grass height; types application frequency, and recommended coverage of fertilizer, and watering schedule to be performed by Solutia.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Products shall be delivered to site to support progress of work.

B. Products shall be stored and protected from deleterious conditions.

C. Grass seed mixture shall be delivered in sealed containers. Seed in damaged packaging is not acceptable.

D. Fertilizer shall be delivered in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.6 MAINTENANCE PERIOD

A. Notwithstanding the Contractor's warranty, the Owner will pay the Contractor a lump sum price to maintain the Work in its accepted condition for one (1) year. The Maintenance Period shall start from the date of the Construction Manager's Final Acceptance. The Contractor's Maintenance Period Work shall include:

1. Supply and placement of fill materials to re-establish final grades and the landfill cover thickness in accordance with the design drawings and specifications.

2. Supply and install E&S controls to minimize erosion of the landfill cover.

3. Establish and maintain successful revegetation of the cover in accordance with this specification.

4. Contractor is responsible for repairing any settlement areas that occur in the 12-month maintenance period.

B. The Contractor's Manager will inspect the grass growth at the end of the Maintenance Period. During the Maintenance Period, the Contractor shall sample the topsoil to develop fertilizer requirement, apply fertilizer, kill grubs and weeds, reseed, and cut the grass.

1.7 SUBMITTALS

A. Contractor shall submit certification that seed mixture conforms to this section and the requirements of the State of Illinois.

B. Contractor shall submit all material and workmanship warranties related to seeding.

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Seed mixture shall conform to Class Type 3 of the Illinois DOT Specifications Section 250.07 Seeding

1.	Alta Fescue or Ky 31	40 lbs/acre
2.	Perennial Ryegrass:	20 lbs/acre
3.	Alsike Clover 2	5 lbs/acre
4.	Birdsfoot Trefoil 2	10 lbs/acre
5.	Andropogon Scoparius	5 lbs/acre
6.	Bouteloua Curtipendula	10 lbs/acre
7.	Fult Salt Grass 7	30 lbs/acre
8.	Oats, Spring	50 lbs/acre

2.2 ACCESSORIES

A. Mulching material shall be dry mulch consisting of straw or hay of one or more of the following types: oat, rye and wheat straw. Only undeteriorated mulch can be readily cut into the soil and shall be used.

B. Fertilizer: Ratio of nitrogen to phosphorous to potassium - 1:1:1.

PART 3 EXECUTION

3.1 INSPECTION

A. Contractor shall verify that prepared soil base is ready to receive the work of this section.

B. Contractor shall certify in writing that the condition of the soil base is ready to receive seeding. Beginning of installation means acceptance of existing site conditions.

3.2 FERTILIZING

A. Contractor shall apply fertilizer at a rate of 270 lbs/acre for combined nutrients.

B. Contractor shall apply fertilizer after smooth raking of topsoil.

C. Contractor shall apply fertilizer at the same time or with same machine as will be used to apply seed.

D. Fertilizer shall be mixed thoroughly into upper 2 inches of topsoil.

E. Contractor shall lightly water fertilized areas to aid the dissipation of fertilizer.

3.3 SEEDING

A. Contractor shall apply seed with a machine that places the seed in direct contact with the soil, packs and covers the seed in one continuous operation. Contractor shall not seed any areas in excess of that which can be mulched on the same day.

B. Contractor shall not sow immediately following rain, when ground is too dry, or during windy periods. Seed operation shall stop when wind speeds exceed 15 mph.

C. Contractor shall select an appropriate roller to facilitate grass growth.

D. Seeding machinery can be mounted on rubber tires or tracks but must maintain a ground pressure not exceeding 8 lbs/sq in.

E. Immediately following seeding and compacting, mulch shall be applied to a thickness of 1/8 inches.

F. Water shall be applied to irrigate the newly seeded ground cover for period of 60 days. The irrigation procedures shall be designed such as the topsoil will be saturated to a depth of at least 4 inches when the system is in use.

3.4 WARRANTY PERIOD

A. The warranty period shall extend for a period of 1 year after acceptance of conditions by the Construction Manager.

B. Contractor shall immediately reseed areas which show bare spots at no additional cost to the Construction Manager.

3.5 SCHEDULE

A. Seeding and fertilizers shall be applied to all areas disturbed during construction.

3.6 SUCCESSFUL REVEGETATION

A. Contractor shall reestablish a diversified, self-sustaining stand of grass that is adapted to the region. The Construction Manager will determine acceptability of the grass growth in accordance with the following:

1. Landfill shall have at least 85% groundcover of permanent grass species.

2. No area or patch greater than 36-inch x 36-inch shall be barren.

3. No trees, wood shrubs or deep-rooted plants shall be allowed to grow on the revegetated areas.

END OF SECTION 02932

APPENDIX F

CONSTRUCTION QUALITY ASSURANCE MANUAL FOR INSTALLATION OF GEOSYNTHETIC COMPONENTS FOR THE SAUGET AREA 1 TSCA LANDFILL

CONSTRUCTION QUALITY ASSURANCE MANUAL FOR INSTALLATION OF GEOSYNTHETIC COMPONENTS FOR THE SAUGET AREA 1 TSCA LANDFILL CAHOKIA, ILLINOIS

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1.1 SCOPE

This Construction Quality Assurance (CQA) Manual addresses the quality assurance of the installation of geosynthetic materials used by Solutia Inc. (Solutia) for the construction of the Sauget Area 1 TSCA Landfill located in Cahokia, Illinois.

This manual addresses quality assurance, not quality control. In the context of this manual, quality assurance refers to means and actions employed to assure conformity of the geosynthetic system production and installation with the project-specific, Plans, Specifications, contractual and regulatory requirements. Quality assurance is provided by a party independent from production and installation. Quality control refers only to those actions taken to ensure that materials and workmanship meet the requirements of the Plans and Specifications. Quality control is provided by the manufacturers and installers of the various components of the geosynthetic system.

The scope of this CQA Manual applies to manufacturing, shipment, handling, and installation of geosynthetics. This CQA Manual does not address design guidelines, installation specifications, or selection of geosynthetic materials. It also does not address the quality assurance of soils, except in cases where soil placement may have an influence on the geosynthetics. The quality assurance of soil components of landfill lining and final cover systems is addressed in Solutia's "Quality Assurance Manual for the Installation of Soil Components of the Lining and Final Cover Systems".

1.2 PROJECT ORGANIZATION

Solutia has the overall responsibility for ensuring that all construction activities fulfill the objectives of the project. Solutia will retain an independent construction management firm to coordinate all construction activities of the Feed Pond closure and construction of the TSCA Landfill. Solutia will also retain an independent inspection firm to provide Construction Quality Assurance services during construction activities. Figure 1-1 presents an organization chart for the project.

Key personnel, their authority and responsibilities with respect to the CQA process are as follows:

1.2.1 Solutia Leadership Team

The Solutia Leadership Team will act as a contact with all regulatory agencies for all matters concerning the project and has overall responsibility for the conduct of project activities. The Solutia Leadership Team will ensure that corporate standards are applied during the project and will have the overall responsibility to ensure the project meets all established QA/QC goals. The Solutia Leadership Team is responsible for the coordination between the design firm and Construction Manager and serves as Solutia's representative during construction. They are also the primary point of contact between Solutia and all supporting team members. The Solutia Leadership Team will perform its duties under the direction of Bruce Yare and Mike Light.

1.2.2 Construction Manager

Acting under the authority delegated to him by Solutia, the Construction Manager is the on-site representative and will implement the overall project plans through day-to-day direction of field activities. Solutia will retain a construction management firm to provide these services.

1.2.3 Designer

The Designer is the individual and/or firm responsible for the preparation of the design, including plans and project-specific specifications for the geosynthetic components of the lining and final cover system. The Designer for the TSCA Landfill is URS Corporation Southern (URS).

1.2.4 Geosynthetic Construction Quality Assurance Consultant

The Geosynthetic Construction Quality Assurance (CQA) Consultant is a firm independent from the Construction Manager, Manufacturer(s), and Installer that shall be responsible for observing and documenting activities related to the quality assurance of the production and installation of the geosynthetic system on behalf of Solutia.

1.2.5 Geosynthetic Quality Assurance Laboratory

The Geosynthetic Quality Assurance Laboratory (QAL) is a firm, independent from the Construction Manager, Manufacturer(s), and Installer, responsible for conducting tests on samples of geosynthetics taken from the site. Solutia will retain an independent laboratory to perform geosynthetic testing for the project.

1.2.6 Construction Contractor(s)

Selected Contractors will be responsible for performing the work outlined in the Plans and Specifications. This work shall include:

- Site mobilization and demobilization
- Site preparation
- Construction of the TSCA Landfill Liner System
- Construction of the TSCA Landfill Cover System

1.3 PROJECT TEAM RESPONSIBILITIES AND QUALIFICATIONS

The parties discussed in this section are associated with the ownership, design, manufacture, transportation, installation, and quality assurance of the geosynthetic system. The qualifications and responsibilities of these parties are outlined in the following subsections.

1.3.1 Construction Manager

1.3.1.1 Responsibilities

The Construction Manager is responsible for all construction quality. The Construction Manager is responsible for the organization and implementation of the quality assurance activities for the project.

The Construction Manager shall serve as communications coordinator for the project, initiating all construction meetings. As communications coordinator, the Construction Manager shall serve as a liaison between all parties involved in the project to insure that communications are maintained.

The principal responsibilities of the Construction Manager are:

- Establish effective communications with the Solutia Leadership Team and Contractor field representatives, and other project team personnel through correspondence, meetings, and discussions, as required, to maintain close working relationships.
- Execute the project work plans and implement procedures through overall planning and day-to-day direction of field activities.
- Ensure that QA and QC procedures are implemented throughout execution of the work.
- Review Contractor progress reports and payments.
- Issue weekly field activity reports.
- Maintain on-site documentation consisting of procedures, rules and regulations, drawings, survey information, correspondence, meetings, etc.
- Manage and assist other field personnel in overseeing Contractors.

The Construction Manger shall also be responsible for proper resolution of all quality assurance issues that arise during construction.

1.3.1.2 Qualifications

The selection of the Construction Manager is the direct responsibility of Solutia. Qualifications for this position include familiarity with the following:

1. Applicable construction methods and procedures.
2. General geosynthetic lining techniques.
3. All applicable regulatory requirements.
4. Company policies and procedures for project management.
5. Quality assurance requirements.

1.3.2 Designer

1.3.2.1 Responsibilities

The Designer is responsible for performing the engineering design and preparing the associated Plans and Specifications for the geosynthetic components of the lining and final cover system. The Designer is responsible for approving all design and specification changes and making design clarifications necessitated during construction of the geosynthetic components of the lining and final cover system.

1.3.2.2 Qualifications

The Designer shall be a qualified engineer, certified or licensed as required by regulation. The Designer shall be familiar with geosynthetics (including detailed geosynthetic design methods and procedures) and applicable regulatory requirements.

1.3.2.3 Submittals

The Designer shall submit the project Plans and Specifications to the Solutia Leadership Team and the Construction Manager.

1.3.3 Manufacturer

1.3.3.1 Definitions

The Manufacturer is a firm responsible for production of any of the various geosynthetic liner system components outlined in the Specifications.

1.3.3.2 Responsibilities

Each Manufacturer is responsible for the production of its geosynthetic product. In addition, each Manufacturer is responsible for the condition of the geosynthetic until the material is accepted by the Construction Manager after delivery. Each Manufacturer shall produce a consistent product meeting the Specifications. Each Manufacturer shall provide quality control documentation for its product as specified in the Specifications.

1.3.3.3 Qualifications

Each Manufacturer shall be pre-qualified by Solutia. Each Manufacturer shall provide sufficient production capacity and qualified personnel to meet the demands of the project. Each Manufacturer shall have an internal quality control program for its product that meets standard industry requirements.

1.3.3.4 Submittals

Pre-qualification: A Manufacturer shall meet the following requirements and submit the following information:

1. A list of material properties including certified test results, to which are attached geosynthetic samples.
2. The origin (supplier's name and production plant) and identification (brand name and number) of resin used to manufacture the product.

Pre-installation: Prior to the installation of any geosynthetic material, a Manufacturer must submit to the Construction Manager all quality control documentation required by the Specifications. This documentation shall be reviewed by the Construction Manager before installation can begin.

1.3.4 Installer

1.3.4.1 Definitions

The Installer is the firm responsible for installation of the geosynthetics. The Installer may be affiliated with the Manufacturer.

The Superintendent is responsible for the Installer's field crew. The Superintendent shall represent the Installer at all site meetings and shall be responsible for acting as the Installer's spokesman on the project.

The Master Seamer shall be the most experienced seamer of the Installer's field crew. The Master Seamer shall provide direct supervision over less experienced seamers.

1.3.4.2 Responsibilities

The Installer shall be responsible for field handling, storing, deploying, seaming, temporary restraining and all other aspects of the geosynthetics installation. The Installer may also be responsible for transportation of these materials from on-site storage to the area of the work.

1.3.4.3 Qualifications

The Installer shall be pre-qualified and approved by Solutia. The Installer shall be able to provide qualified personnel to meet the demands of the project. At a minimum, the Installer shall provide a Superintendent and a Master Seamer as described below.

The Superintendent and Master Seamer must be qualified based on previously demonstrated experience, management ability, and authority.

For geomembrane installation all personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests using the equipment and seaming techniques proposed for this project.

1.3.4.4 Submittals

Pre-qualification: To be considered for pre-qualification, the Installer shall submit the pre-qualification information required by the Specifications.

Pre-installation: Prior to commencement of the installation, the Installer must submit to the Construction Manager:

1. Resume of the Superintendent to be assigned to this project, including dates and duration of employment.
2. Resume of the Master Seamer to be assigned to this project, including dates and duration of employment.
3. A panel layout drawing showing the installation layout identifying field seams as well as any variance or additional details which deviate from the engineering drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc.
4. Installation schedule.
5. A list of personnel performing field seaming operations along with pertinent experience information.
6. All geosynthetic quality control certificates as required by this QAM (unless submitted directly to the Construction Manager by the Manufacturer).
7. Certification that extrudate to be used is comprised of the same resin as the geomembrane to be used.

This documentation shall be reviewed by the Construction Manager before installation of the geosynthetic can begin.

Installation: During the installation, the Installer shall be responsible for the submission of:

1. Quality control documentation recorded during installation.
2. Subgrade surface acceptance certificates for each area to be covered by the lining system, signed by the Installer.

Completion: Upon completion of the installation, the Installer shall submit:

1. The warranty obtained from the Manufacturer.
2. The installation warranty.

1.3.5 Geosynthetic Construction Quality Assurance Consultant

1.3.5.1 Responsibilities

The Geosynthetic Construction Quality Assurance (CQA) Consultant is responsible for observing and documenting activities related to the quality assurance of the production and installation of the geosynthetic system. The Geosynthetic CQA Consultant is responsible for implementation of the project CQA Manual and management of the Geosynthetic Quality Assurance Laboratory. The Geosynthetic CQA Consultant is also responsible for issuing a final certification report sealed by a registered professional engineer.

The specific duties of the Geosynthetic CQA Consultant personnel are as follows:

1. Reviews other site-specific documentation, including proposed layouts, and manufacturer's and installer's literature.
2. Reviews all changes to design drawings and specifications as issued by the Designer.
3. Attends all quality assurance related meetings.
4. Reviews all Manufacturer and Installer certifications and documentation and makes appropriate recommendations.
5. Reviews the Installer's personnel qualifications for conformance with the qualifications for work on site.
6. Reviews the calibration certification of the on-site tensiometer, if applicable.
7. Notes any on site activities that could result in damage to the geosynthetics.
8. Reports to the Construction Manager, and logs in the daily report.
9. Prepares a daily summary of the quantities of geosynthetics installed that day.
10. Prepares the weekly summary of geosynthetic quality assurance activities.
11. Oversees the marking, packaging and shipping of all laboratory test samples.
12. Reviews the results of laboratory testing and makes appropriate recommendations.
13. Reports any unapproved deviations from the CQA Manual to the Construction Manager.
14. Prepares the final certification report.

1.3.5.2 Qualifications

The Geosynthetic CQA Consultant shall be pre-qualified by Solutia. The Geosynthetic CQA Consultant shall be experienced in quality assurance of geosynthetics. The Geosynthetic CQA Consultant shall be experienced in the preparation of quality assurance documentation including: quality assurance forms, reports, certifications, and manuals.

1.3.5.3 Submittals

Pre-qualification: To be considered for pre-qualification, the Geosynthetic CQA Consultant must provide the following information:

1. Corporate background and information.
2. Quality assurance capabilities:
   a. A summary of the firm's experience with geosynthetics.
   b. A summary of the firm's experience in quality assurance, including installation quality assurance of geosynthetics.
   c. A summary of quality assurance documentation and methods used by the firm, including sample quality assurance forms, reports, certifications, and manuals prepared by the firm.
   d. Resumes of key personnel.

Pre-installation: Prior to beginning work on a project, the Geosynthetic CQA Consultant must provide the Construction Manager with the following information:

1. Resumes of personnel to be involved in the project.
2. Proof of the required quality assurance experience of all of the quality assurance personnel.

1.3.6 Geosynthetic Quality Assurance Laboratory

1.3.6.1 Responsibilities

The Geosynthetic QAL shall be responsible for conducting the appropriate laboratory tests as directed by the Geosynthetic CQA Consultant or the Construction Manager. The test procedures shall be done in accordance with the test methods outlined in the Plans and Specifications. The Geosynthetic QAL shall be responsible for providing test results.

1.3.6.2 Qualifications

The Geosynthetic QAL shall have experience in testing geosynthetics and be familiar with American Society for Testing and Materials (ASTM), and other applicable test standards. The Geosynthetic QAL shall be capable of providing verbal results of destructive seam tests within 24 hours of receipt of test samples and shall maintain that standard throughout the installation. The Geosynthetic QAL shall be approved by Solutia.

On-site laboratory facilities may be used by the Geosynthetic QAL provided they are appropriately equipped and approved by the Geosynthetic QAC and the Construction Manager.

1.3.6.3 Submittals

Geomembrane destructive test results shall typically be provided verbally to the Construction Manager within 24 hours of receipt of test samples. The Geosynthetic QAL shall submit all destructive seam test results to the Construction Manager in written form within 48 hours of receipt of test samples unless otherwise specified by the Construction Manager. Written test results shall be in an easily readable format and include references to the standard test methods used.

1.4 COMMUNICATION

To guarantee a high degree of quality during installation and assure a final product that meets all project specifications, clear, open channels of communication are essential. This section issues appropriate lines of communication and describes all necessary meetings.

1.4.1 Resolution Meeting

Following the completion of the construction drawings and specifications for the project, a resolution meeting may be held. If a resolution meeting is required, it is recommended that the meeting be held prior to bidding the construction work and include all parties then involved, typically including the Construction Manager, Designer, Geosynthetic CQA Consultant, and a Solutia Leadership Team representative. If necessary, this meeting can be held in conjunction with the pre-construction meeting.

The purpose of this meeting is to establish lines of communication, review construction drawings and specifications for completeness and clarity, begin planning for coordination of tasks, and anticipate any problems which might cause difficulties and delays in construction. All aspects of the design shall be reviewed during this meeting so that clarification and/or design changes may be made before the construction work is bid. In addition, the guidelines regarding quality assurance testing and problem resolution must be known and accepted by all.

A recommended agenda for the resolution meeting is presented in Exhibit 1-1. The meeting shall be documented by the Construction Manager and minutes shall be transmitted to all parties.

1.4.2 Pre-construction Meeting

A pre-construction meeting shall be held at the site prior to beginning geosynthetic deployment. Typically, the meeting shall be attended at a minimum by the Construction Manager, Designer, Installer, and Geosynthetic CQA Consultant.

Specific topics considered for this meeting include review of the project CQA Manual for any problems or additions. In addition, the responsibilities of each party should be reviewed and understood clearly. A recommended agenda with specific topics for the pre-construction meeting is presented in Exhibit 1-2. The meeting shall be documented by the Construction Manager and minutes shall be transmitted to all parties.

1.4.3 Progress Meetings

A progress meeting shall be held at least weekly between the Geosynthetic CQA Consultant, Installer's Superintendent, Construction Manager, and any other concerned parties. This meeting shall discuss current progress, planned activities for the next week, issues requiring resolution, and any new business or revisions to the work. The Geosynthetic CQA Consultant shall log any problems, decisions, or questions arising at this meeting in his weekly report. If any matter remains unresolved at the end of this meeting, the Construction Manager shall be responsible for the resolution of the matter and the communication of the decision to the appropriate parties.

2.1 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geomembrane material, the Manufacturer or Installer shall provide the Construction Manager with the following information:

1. The origin (resin suppliers name and resin production plant), identification (brand name and number), and production date of the resin.
2. Copies of the quality control certificates issued by the resin supplier.
3. Reports on tests conducted by the Manufacturer to verify that the quality of the resin used to manufacture the geomembrane meets the Specifications.
4. Reports on quality control tests conducted by the Manufacturer to verify that the geomembrane manufactured for the project meets the project specifications.
5. A statement indicating that no reclaimed polymer was added to the resin during manufacturing.
6. A list of the materials with which comprise the geomembrane, expressed in the following categories as percent by weight: polyethylene, carbon black, other additives.
7. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.
8. Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, sampling procedures, and results of quality control tests. At a minimum, results shall be for:

   a. Density

   b. Carbon black content

   c. Carbon black dispersion

   d. Thickness

   e. Tensile properties

   f. Tear resistance

These quality control tests shall be performed in accordance with the frequency and test methods in the Specifications.

The Manufacturer shall identify all rolls of geomembranes with the following:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Roll number
5. Roll dimensions

The Geosynthetic CQA Consultant shall review these documents and shall report any discrepancies with the above requirements to the Construction Manager. The Geosynthetic CQA Consultant shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed performance criteria. Measurements of properties by the Manufacturer are properly documented and that test methods used are acceptable.
2. Quality control certificates have been provided at the specified frequency for all rolls and that each certificate identifies the rolls related to it.
3. Rolls are appropriately labeled.
4. Certified minimum properties meet the requirement of the Specifications.

2.2 CONFORMANCE TESTING

Upon delivery of the rolls of geomembrane, the Geosynthetic CQA Consultant shall ensure conformance test samples are obtained for the geomembrane. These samples shall be that forwarded to the Geosynthetic QAL for testing to ensure conformance to the Specifications. If the Construction Manager desires, the Geosynthetic CQA Consultant can direct the conformance sampling be completed at the manufacturing plant.

The following conformance tests shall be conducted:

1. Density
2. Carbon black content
3. Carbon black dispersion
4. Thickness
5. Tensile characteristics
6. Asperity height
7. Interface friction between textured geomembrane/geosynthetic clay liner, textured geomembrane/ geonet, smooth geomembrane/geonet, and smooth geomembrane/soil.

These conformance tests shall be performed in accordance with the test frequency and methods in the Specifications.

2.2.1 Sampling Procedures

The rolls to be sampled shall be selected by the Geosynthetic CQA Consultant. Samples shall be taken across the entire width of the roll and shall not include the first 3 ft (1 m). Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic CQA Consultant shall mark the machine direction on the samples with an arrow.
A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic CQA Consultant based on a review of all roll information including quality control documentation manufacturing records.

2.2.2 Liner System Shear Box Testing

Prior to acceptance by the Geosynthetic CQA Consultant or the Construction Manager, the Contractor shall submit information documenting the interface friction values of the selected geosynthetics. Interface friction values shall be determined for the selected material combination provided by the Specifications. Interface friction data shall be submitted by the Contractor for review and approval within 30 days of contract award.

The Construction Manager will review the documentation for conformance with the requirements of the design. This conformance test shall be performed in accordance with the requirements of the Specifications as per ASTM D 5321.

2.2.3 Test Results

All conformance test results shall be reviewed and by the Geosynthetic CQA Consultant prior to the deployment of the geomembrane. The Geosynthetic CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the Construction Manager. The Geosynthetic CQA Consultant shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications. Based upon the recommendation of the Geosynthetic CQA Consultant, the Construction Manager shall accept or reject the geomembrane.

If the Manufacturer has reason to believe that failing tests may be the result of Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. This retesting shall be done at the expense of the Manufacturer. Alternatively, the Manufacturer may have the sample retested at two different Solutia approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to approval of the Construction Manager.

If a test result is in nonconformance, all material from the lot represented by the failed test should be considered out of specification and rejected. Alternatively, at the option of the Construction Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specifications (note that this procedure is valid only when rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out of specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

2.3 SUBGRADE PREPARATION

2.3.1 Surface Preparation

The Earthwork Contractor shall be responsible for preparing the supporting soil for geomembrane placement. The Construction Manager shall coordinate the work of the Earthwork Contractor and the Installer so that the requirements of the Specifications and the project CQA Manual are met.

Before the geomembrane installation begins, the Geosynthetic CQA Consultant shall verify that:

1. A qualified land surveyor has verified all lines and grades.
2. A qualified geotechnical engineer has verified that the supporting soil meets the density specified in the project specifications.
3. The surface to be lined has been rolled, compacted, or handworked so as to be free irregularities, protrusions, loose soil and abrupt changes in grade. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.
4. The surface of the supporting soil does not contain stones which may be damaging the geomembrane.
5. There is no area excessively softened by high water content.
6. There is no area where the surface of the soil contains desiccation cracks with dimensions exceeding those allowed by the Specifications.

The Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. A certificate of acceptance shall be given by the Installer to the Geosynthetic CQA Consultant and Construction Manager prior to commencement of geomembrane deployment in the area under consideration.

After the supporting soil has been accepted by the Installer, it is the Installer's responsibility to indicate to the Construction Manager any change in the supporting soil condition that may require repair work. The Construction Manager may consult with the Geosynthetic CQA Consultant regarding the need for repairs. The Construction Manager shall ensure that the supporting soil is repaired.

At any time before or during the geomembrane installation, the Geosynthetic CQA Consultant shall indicate to the Construction Manager any locations which may not be adequately prepared for the geomembrane.

2.3.2 Anchor Trench

The Geosynthetic CQA Consultant shall verify that the anchor trench has been constructed according to the design Plans and Specifications.

If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of trench open at any time should be minimized. The Geosynthetic CQA Consultant shall inform the Construction Manager of any signs of significant desiccation associated with the anchor trench construction.

Slightly rounded corners shall be provided in the trench so as to avoid sharp bends in the geomembrane. Excessive amounts of loose soil shall not be allowed to underlie geomembrane in the anchor trench.

The anchor trench shall be adequately drained to prevent ponding or softening of adjacent sods while the trench is open. The anchor trench shall be backfilled and compacted as outlined in the project specifications.

Care shall be taken when backfilling the trenches to prevent any damage to geosynthetics. The Geosynthetic CQA Consultant shall observe the backfilling operation and advise the Construction Manager of any problems. Any problems shall be documented by the Geosynthetic CQA Consultant in his daily report.

2.4 GEOMEMBRANE DEPLOYMENT

2.4.1 Panel Nomenclature

A field panel is defined as a unit of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field.

It shall be the responsibility of the Geosynthetic CQA Consultant to ensure that each field panel be given an identification code (number or letter-number) consistent with the layout plan. This identification code shall be agreed upon by the Construction Manager, Installer and Geosynthetic CQA Consultant. This field panel identification code shall be as simple and logical as possible. In general, it is not appropriate to identify panels using roll numbers since numbers established in the manufacturing plant are usually cumbersome and are related to location in the field. The Geosynthetic CQA Consultant shall establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

The Geosynthetic CQA Consultant shall verify that field panels are installed at the locations indicated on the Installer's layout plan, as approved by the Construction Manager.

2.4.2 Panel Deployment Procedure

The Geosynthetic CQA Consultant shall review the panel deployment progress of the Installer (keeping in mind issues relating to wind, rain, clay liner desiccation, and other site-specific conditions) and advise the Construction Manager on its compliance with the approved panel layout drawing and its suitability to the actual field conditions. Once approved, only the Construction Manager can authorize changes to the panel deployment procedure. Geosynthetic CQA Consultant shall verify that the condition of the supporting soil does not change detrimentally during installation.

The Geosynthetic CQA Consultant shall record the identification code, location, and date of installation of each field panel.

2.4.3 Deployment Weather Conditions

Geomembrane deployment shall not proceed at an ambient temperature below 32° F (0° C) or above 104° F (40° C) unless otherwise authorized, in writing, by the Construction Manager. Geomembrane placement shall not be performed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds. Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment.

The Geosynthetic CQA Consultant shall verify that the above conditions are fulfilled. Ambient temperature shall be measured by the Geosynthetic CQA Consultant in the area in which the panels are to be deployed. The Geosynthetic CQA Consultant shall inform the Construction Manager of any weather related problems which may not allow geomembrane placement to proceed.

2.4.4 Method of Deployment

Before the geomembrane is handled on site, the Geosynthetic CQA Consultant shall verify that handling equipment to be used on the site is adequate and does not pose risk of damage to the geomembrane. During handling, the Geosynthetic CQA Consultant shall observe and verify that the Installer's personnel handle the geomembrane with care.

The Geosynthetic CQA Consultant shall verify the following:

1. Any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means.
2. The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement.
3. Any geosynthetic elements immediately underlying the geomembrane are clean and free of debris.
4. All personnel do not smoke or wear damaging shoes while working on the geomembrane, or engage in other activities which could damage the geomembrane.

5. The method used to unroll the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting soil.
6. The method used to place the panels minimized wrinkles (especially differential wrinkles between adjacent panels).
7. Adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind. In case of winds, continuous loading, e.g., by sand bags, is recommended along edges of panel to minimize risk of wind flow under the panels.
8. Direct contact with the geomembrane is minimized, and the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

The Geosynthetic CQA Consultant shall inform the Construction Manager if the above conditions are not fulfilled.

2.4.5 Damage and Effects

Upon delivery to the site, the Geosynthetic CQA Consultant shall conduct a surface observation of all rolls for defects and for damage. This inspection shall be conducted without unrolling rolls unless defects or damages are found or suspected. The Geosynthetic CQA Consultant shall advise the Construction Manager, in writing, of any rolls or portions of rolls which should be rejected and removed from the site because they have severe flaws, and/or minor repairable flaws.

The Geosynthetic CQA Consultant shall inspect each panel, after placement and prior to seaming, for damage and/or defects. The Geosynthetic CQA Consultant shall advise the Construction Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels, or portions of damaged panels, which have been rejected shall be marked and their removal from the work area recorded by the Geosynthetic CQA Consultant. Repairs shall be made using procedures described in the Specifications.

2.4.6 Writing on the Liner

To avoid confusion, the Installer and the Geosynthetic CQA Consultant shall each use different colored markers that are readily visible for writing on the geomembrane. The markers used must be semi-permanent and compatible with the geomembrane. The installer shall use a yellow marker to write on the geomembrane. The Geosynthetic CQA Consultant shall use a red marker.

2.5 FIELD SEAMING

2.5.1 Seam Layout

Before installation begins, the Installer must provide the Construction Manager and the Geosynthetic CQA Consultant with a panel layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The Geosynthetic CQA Consultant shall review the panel layout drawing and verify that it is consistent with accepted state-of-practice. No panels may be seamed without written approval of the panel layout drawing by the Construction Manager. In addition, panels not specifically shown on the panel layout drawing may not be used without the Construction Manager's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized by the Construction Manager.

A seam numbering system compatible with the panel numbering system shall be used by the Geosynthetic CQA Consultant.

2.5.2 Accepted Seaming Methods

Approved processes for field seaming are extrusion welding and fusion welding. Fusion double seam welding is the preferred method for joining long, straight seams. Extrusion welding is the preferred seaming method in areas such as corners, sumps, pipe penetrations, tear repairs and cap strips where fusion double seam welding is not feasible. Use of extrusion welding shall be minimized to the extent possible. Proposed alternate processes shall be documented and submitted by the Installer to the Construction Manager for approval. Only apparatus which have been specifically approved by make and model shall be used. The Construction Manager shall submit all documentation regarding seaming methods to be used to the Geosynthetic CQA Consultant for review.

2.5.2.1 Extrusion Process

The Geosynthetic CQA Consultant shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the construction manager.

The Geosynthetic CQA Consultant shall verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus decided upon at the pre-construction meeting.
2. Equipment used for seaming is not likely to damage the geomembrane.
3. Prior to beginning a seam, the extruder is purged until all heat-degraded extrudate has been removed from the barrel.
4. Clean and dry welding rods or extrudate pellets are used.
5. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.
6. Grinding shall be completed no more than 1 hour prior to seaming.

7. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage.
8. The geomembrane is protected from damage in heavily trafficked areas.
9. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instance shall exposed grinding marks extend more than ¼-inch from the seamed area.
10. In general, the geomembrane panels are aligned to have a nominal overlap of 3 inches (75 mm) for extrusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.
11. No solvent or adhesive is used unless the product is approved in writing by the construction manager prior to use (samples shall be submitted to the construction manager for testing and evaluation).
12. The procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any temporary welding apparatus is controlled such that the geomembrane is not damaged or degraded.

2.5.2.2 Fusion Process

The Geosynthetic CQA Consultant shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the construction manager.

The Geosynthetic CQA Consultant shall also verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus decided upon at the pre-construction meeting.
2. Equipment used for seaming is not likely to damage the geomembrane.
3. For cross seams, the edge of the cross seam is ground to an incline prior to welding.
4. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.
5. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage.
6. The geomembrane is protected from damage in heavily trafficked areas.
7. A movable protective layer is used as required by the installer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between the sheets and prevent debris from collecting around the pressure rollers.
8. In general, the geomembrane panels are aligned to have a nominal overlap of 5 inches (125 mm) for fusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.
9. No solvent or adhesive is used unless the product is approved in writing by the Construction Manager prior to use (samples shall be submitted to the Construction Manager for testing and evaluation).

2.5.3 Seam Preparation

The Geosynthetic CQA Consultant shall verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the Geosynthetic CQA Consultant must ensure that the process is completed according to the manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane. The Geosynthetic CQA Consultant shall also verify that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

2.5.4 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours, for each production seaming apparatus used that day. Each seamer shall make at least one trial seam each day. Trial seams shall be made under the same conditions as actual seams.

The trial seam sample shall be at least 5 ft (1.0 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as indicated in Section 4.6.2.

Two specimens shall be cut from the sample with a 1-inch (25 mm) wide die. The specimens shall be cut by the installer at locations selected randomly along the trial seam sample by the Geosynthetic CQA Consultant. The specimens shall be tested in peel using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. They should not fail in the seam. If a specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial welds are achieved. The Geosynthetic CQA Consultant shall observe all trial seam procedures.

The remainder of the successful trial seam sample shall be cut into three pieces, one to be retained in the construction manager's archives, one to be given to the installer, and one to be retained by the Geosynthetic CQA Consultant for possible laboratory testing. Each portion of the sample shall be assigned a number and marked accordingly by the Geosynthetic CQA Consultant, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

If agreed upon between the Construction Manager and the Geosynthetic CQA Consultant, and documented by the Geosynthetic CQA Consultant in his/her daily report, the remaining portion of the trial seam sample can be subjected to destructive testing. If a trial seam sample fails a test conducted by the Geosynthetic QAL, then a destructive seam test sample shall be taken from each of the seams completed by the seamer during the shift related to the considered trial seam. These samples shall be forwarded to the Geosynthetic QAL and, if they fail the tests, the seam shall be subjected to the "Destructive Test Failure Procedures" identified in this CQA Manual.

The conditions of this paragraph shall be considered satisfied for a given seam if a destructive seam test sample has already been taken.

2.5.5 General Seaming Procedures

During general seaming, the Geosynthetic CQA Consultant shall be cognizant of the following:

1. For fusion welding, it may be necessary to place a movable protective layer of plastic directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture buildup between the sheets to be welded and prevent debris from collecting around the pressure rollers.
2. If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.
3. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches (150 mm) beyond the cut in all directions.
4. If seaming operations are carried out at night, adequate illumination shall be provided.
5. Seaming shall extend to the outside edge of panels placed in the anchor trench.
6. All cross seam tees should be extrusion welded to a minimum distance of 4 inches on each side of the tee.
7. No field seaming shall take place without the master seamer being present.

The Geosynthetic CQA Consultant shall verify that the approved seaming procedures are followed, and shall inform the Construction Manager of any nonconformance.

2.5.6 Seaming Weather Conditions

2.5.6.1 Normal Weather Conditions

The normal required weather conditions for seaming are as follows:

1. Ambient temperature between 32° F (0° C) and 104° F (40° C).
2. Dry conditions (i.e., no precipitation or other excessive moisture, such as fog or dew).
3. No excessive winds.

The Geosynthetic CQA Consultant shall verify that these weather conditions are fulfilled and notify the Construction Manager in writing if they are not. Ambient temperature shall be measured by the Geosynthetic CQA Consultant in the area in which the panels are to be placed. The Construction Manager will then decide if the installation is to be stopped or special procedures used.

2.5.6.2 Cold Weather Conditions

To ensure a quality installation, if seaming is conducted when the ambient temperature is below 32° F (0° C), the following conditions must be met:

1. Geomembrane surface temperatures shall be determined by the Geosynthetic CQA Consultant at intervals of at least once per 100 foot of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32° F (0° C).
2. Preheating may be waived by the construction manager based on a recommendation from the Geosynthetic CQA Consultant, if the installer demonstrates to the Geosynthetic CQA Consultant's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.
3. If preheating is required, the Geosynthetic CQA Consultant shall inspect all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.
4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.
5. All preheating devices shall be approved prior to use by the construction manager.
6. Additional destructive tests shall be taken at an interval between 500 and 250 feet of seam length, at the discretion of the Geosynthetic CQA Consultant.
7. Sheet grinding may be performed before preheating, if applicable.
8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the actual seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 5° F from the initial trial seam test conditions.

2.5.6.3 Warm Weather Conditions

At ambient temperatures above 104° F, no seaming of the geomembrane shall be permitted unless the installer can demonstrate to the satisfaction of the construction manager that geomembrane seam quality is not compromised.

Trial seaming shall be conducted under the same ambient temperature conditions as the actual seams.

At the option of the Geosynthetic CQA Consultant, additional destructive tests may be required for any suspect areas.

2.6 NONDESTRUCTIVE SEAM TESTING

2.6.1 Concept

The Installer shall nondestructively test all field seams over their full length using a vacuum test unit, air pressure test (for double fusion seams only), or other approved method. The purpose of nondestructive tests is to check the continuity of seams. It does not provide quantitative information on seam strength. Nondestructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

For all seams, the Geosynthetic CQA Consultant shall:

1. Observe nondestructive testing procedures.
2. Record location, data, test unit number, name of tester, and outcome of all testing.
3. Inform the Installer and Construction Manager of any required repairs.

Any seam that cannot be nondestructively tested shall be cap-stripped with the same geomembrane. The cap-stripping operations shall be observed by the Geosynthetic CQA Consultant and Installer for uniformity and completeness.

2.6.2 Vacuum Testing

The following procedures are applicable to vacuum testing.

1. The equipment shall consist of the following:
   a. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a porthole or valve assembly, and a vacuum gauge.
   b. A pump assembly equipped with a pressure controller and pipe connections.
   c. A rubber pressure/vacuum hose with fittings and connections.
   d. A soapy solution.
   e. A bucket and wide paint brush, or other means of applying the soapy solution.
2. The following procedures shall be followed:
   a. Energize the vacuum pump and reduce the tank pressure to approximately 5 psi (10 in. of Hg) (35 kPa) gauge.
   b. Wet a strip of geomembrane approximately 12 inches x 48 inches (0.3 m x 1.2 m) with the soapy solution.
   c. Place the box over the wetted area.
   d. Close the bleed valve and open the vacuum valve.

e. Ensure that a leak-tight seal is created.

f. For a period of not less than 10 seconds, apply vacuum and examine the geomembrane through the viewing window for the presence of soap bubbles.

g. If no bubble appears after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inches (75 mm) overlap, and repeat the process.

h. All areas where soap bubbles appear shall be marked and repaired.

2.6.3 Air Pressure Testing

The following procedures are applicable to double fusion welding which produces a double seam with an enclosed space.

1. The equipment shall consist of the following:

   a. An air pump (manual or motor driven), equipped with pressure gauge capable of generating and sustaining a pressure between 25 and 30 psi (160 and 200 kPa) and mounted on a cushion to protect the geomembrane.

   b. A rubber hose with fittings and connections.

   c. A sharp hollow needle, or other approved pressure feed device.

2. The following procedures shall be followed:

   a. Seal both ends of the seam to be tested.

   b. Insert needle or other approved pressure feed device into the air channel created by the fusion weld.

   c. Insert a protective cushion between the air pump and the geomembrane.

   d. Energize the air pump to a pressure between 25 and 30 psi (160 and 200 kPa), close valve, allow 2 minutes for pressure to stabilize, and sustain pressure for at least 5 minutes.

   e. If loss of pressure exceeds 4 psi (30 kPa) or does not stabilize, locate faulty area and repair in accordance with Section 4.9.3.

   f. Cut opposite end of tested seam area once testing is completed to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area. Seal the cut end of the air channel.

   g. Remove needle or other approved pressure feed device and seal.

2.6.4 Test Failure Procedure

The Installer shall complete any required repairs in accordance with the requirements of the Specifications. For repairs, the Geosynthetic CQA Consultant shall:

1. Observe the repair and testing of the repair.

2. Mark on the geomembrane that the repair has been made.
3. Document the repair procedures and test results.

2.7 DESTRUCTIVE SEAM TESTING

2.7.1 Concept

Destructive seam tests shall be performed at selected locations in accordance with the requirements of the Specifications. The purpose of these tests is to evaluate seam strength. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

2.7.2 Location and Frequency

The Geosynthetic CQA Consultant shall select locations where seam samples will be cut out for laboratory testing. Those locations shall be established as follows:

1. A minimum frequency of one test location per 500 ft (150 m) of seam length performed by each welder. This minimum frequency is to be determined as an average taken throughout the entire facility.
2. Test locations shall be determined during seaming at the Geosynthetic CQA Consultant's discretion. Selection of such locations may be prompted by suspicion of overheating, contamination, offset welds, or any other potential cause of imperfect welding.
3. One additional CQA destructive seam test will be performed for every 10 destructive tests required by the specifications with a minimum of two CQA destructive tests per geomembrane layer.

The Installer shall not be informed in advance of the locations where the seam samples will be taken.

2.7.3 Sampling Procedures

Samples shall be cut by the Installer at locations chosen by the Geosynthetic CQA Consultant as the seaming progresses so that laboratory test results are available before the geomembrane is covered by another material. The Geosynthetic CQA Consultant shall:

1. Observe sample cutting.
2. Assign a number to each sample, and mark it accordingly.
3. Record sample location on layout drawing.
4. Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in the Specification. The continuity of the new seams in the repaired area shall be tested.

2.7.4 Sample Dimensions

At a given sampling location, two types of samples shall be taken by the Installer. First, two samples for field testing should be taken. Each of these samples shall be cut with a 1-inch (25 mm) wide die, with the seam centered parallel to the width. The distance between these two samples shall be 42 inches (1.1 m). If both samples pass the field test described in Section 4.8.5, a sample for laboratory testing shall be taken.

The sample for laboratory testing shall be located between the samples for field testing. The sample for laboratory testing shall be 12 inches (0.3 m) wide by 42 inches (1.1 m) long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

1. One portion to the Installer for optional laboratory testing, 12 inches x 12 inches (0.3 m x 0.3 m)
2. One portion for Geosynthetic QAL testing, 12 inches x 18 inches (0.3 m x 0.5 m) and
3. One portion to the Construction Manager for archive storage, 12 inches x 12 inches (0.3 m x 0.3 m).

Final determination of the sample sizes shall be made at the pre-construction meeting.

2.7.5 Field Testing

The two 1-inch (25 mm) wide strips shall be tested in the field using a tensiometer for peel and shall not fail according to the criteria in the Specifications. The tensiometer shall be capable of maintaining a constant jaw separation rate of 2 in. per minute. If the test passes in accordance with this section, the sample qualifies for testing in the laboratory. If it fails, the seam should be repaired. Final judgement regarding seam acceptability, based on the failure criteria shall be made by the Construction Manager.

The Geosynthetic CQA Consultant shall witness all field tests and mark all samples and portions with their number. The Geosynthetic CQA Consultant shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description, and attach a copy to each sample portion.

2.7.6 Laboratory Testing

Destructive test samples shall be packaged and shipped, if necessary, under the responsibility of the Geosynthetic CQA Consultant in a manner which will not damage the test sample. The Construction Manager will be responsible for storing the archive samples. Test samples shall be tested by the Geosynthetic QAL.

Testing shall include "seam strength" and "peel adhesion". These terms are defined in the specifications. The minimum acceptable values to be obtained in these tests are indicated in the Specifications. At least 5 specimens shall be tested in each shear and peel. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). A passing test shall meet the minimum acceptable values in at least 4 of the 5 specimens tested for each method.

The Geosynthetic QAL shall provide verbal test results no more than 24 hours after they receive the samples. The Geosynthetic CQA Consultant shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Construction Manager.

2.7.7 Destructive Test Failure Procedures

The following procedures shall apply whenever a sample fails a destructive test, whether that test is conducted by the Geosynthetic QAL, or by field tensiometer. The Installer has two options:

1. The Installer can repair the seam between any two passing test locations.
2. The Installer can trace the welding path to an intermediate location (at 10 ft (3 m) minimum from the point of the failed test in each direction) and take a sample with a 1 in. (25 mm) wide die for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is repaired between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be repaired.

All acceptable repaired seams shall be bound by two locations from which samples passing laboratory destructive tests have been taken. Passing laboratory destructive tests of trial seam samples taken as indicated in Section 4.6.4 may be used as a boundary for the failing seam. In cases exceeding 150 ft (50 m) of repaired seam, a sample taken from the zone in which the seam has been repaired must pass destructive testing. Repairs shall be made in accordance with Specifications.

The Geosynthetic CQA Consultant shall document all actions taken in conjunction with destructive test failures.

2.8 DEFECTS AND REPAIRS

2.8.1 Identification

All seams and non-seam areas of the geomembrane shall be examined by the Geosynthetic CQA Consultant for identification of defects, holes, busters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be cleaned by the installer if the amount of dust or mud inhibits examination.

2.8.2 Evaluation

Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in the Specifications as appropriate. Each location which fails the nondestructive testing shall be marked by the Geosynthetic CQA Consultant and repaired by the installer. Work shall not proceed with any materials which will cover locations which have been repaired until appropriate nondestructive and laboratory test results with passing values are available.

2.8.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Construction Manager, Installer, and Geosynthetic CQA Consultant.

1. The repair procedures available include:
    a. Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
    b. Spot welding or seaming, used to repair small tears, pinholes, or other minor, localized flaws.
    c. Capping, used to repair large lengths of failed seams.
    d. Extrusion welding the flap, used to repair areas of inadequate fusion seams, which have an exposed edge. Repairs of this type shall be approved by the Geosynthetic CQA Consultant, and shall not exceed 50 ft (15 m) in length.
    e. Removing bad seam and replacing with a strip of new material welded into place.
2. For any repair method, the following provisions shall be satisfied:
    a. Surfaces of the geomembrane which are to be repaired using extrusion methods shall be abraded no more than one hour prior to the repair.
    b. All surfaces shall be clean and dry at the time of the repair.
    c. All seaming equipment used in repairing procedures shall meet the requirements of the project CQA Manual.
    d. Patches or caps shall extend at least 6 inches (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches (75 mm).

2.8.4 Repair Verification

Each repair shall be numbered and logged. Each repair shall be nondestructively tested using the methods described in the Specifications as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs more than 150 ft long may be of sufficient extent to require destructive test sampling, at the discretion of the Geosynthetic

CQA Consultant. Failed tests indicate that the repair shall be redone and retested until a passing test results. The Geosynthetic CQA Consultant shall observe all nondestructive testing of repairs and shall record the number of each repair, date, and test outcome.

2.8.5 Large Wrinkles

When seaming of the geomembrane is completed, and prior to placing overlying materials, the Geosynthetic CQA Consultant shall indicate to the Construction Manager which wrinkles should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be, kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation process, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. The geomembrane will be inspected for wrinkles every morning by the Geosynthetic CQA Consultant and the results of the inspection will be documented. On completion of geomembrane installation, it will be inspected for wrinkles by the Geosynthetic CQA Consultant and the Agency and the results of this inspection will be video recorded with a date stamp. Unacceptably large wrinkles will be removed after this final inspection. Wrinkles are considered to be large when the geomembrane can be folded over on to itself. Seams produced while repairing wrinkles shall be tested as outlined above.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Geosynthetic CQA Consultant to ensure that wrinkle formation is minimized.

2.9 GEOMEMBRANE PROTECTION

The quality assurance procedures indicated in this section are intended only to assure that the installation of adjacent materials does not damage the geomembrane. The quality assurance of the adjacent materials themselves should be covered in separate sections of the project CQA Manual as necessary.

2.9.1 Soils

A copy of the specifications prepared by the designer for placement of soils shall be given to the Geosynthetic CQA Consultant by the Construction Manager. The Geosynthetic CQA Consultant shall verify that these specifications are consistent with the state-of-practice such as:

1. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 32° F (0° C) nor above 104° F (40° C) unless otherwise specified.
2. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.
3. A geotextile or other cushion approved by the designer is generally required between aggregate and the geomembrane.
4. Equipment used for placing soil shall not be driven directly on the geomembrane.

5. A minimum thickness of 1 ft (0.3 m) of soil is specified between a light dozer (ground pressure of 5 psi (35 kPa) or lighter) and the geomembrane.
6. In any areas traversed by any vehicles other than low ground pressure vehicles approved by the Construction Manager, the soil layer shall have a minimum thickness of 3 ft (0.9 m). This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

The Geosynthetic CQA Consultant shall measure soil thickness and verify that the required thicknesses are present. The Geosynthetic CQA Consultant must also verify that final thicknesses are consistent with the design and verify that placement of the soil is done in such a manner that geomembrane damage is unlikely. The Geosynthetic CQA Consultant shall inform the Construction Manager if the above conditions are not fulfilled.

3.1 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geotextile, the Manufacturer or Installer shall provide the Construction Manager with the following information:

1. The origin (resin supplier's name and resin production plant) and identification (brand name and number) of the resin used to manufacture the geotextile.
2. Copies of the quality control certificates issued by the resin supplier.
3. Reports on quality control tests conducted by the Manufacturer to verify that the geotextile manufactured for the project meets the project specifications.
4. A specification for the geotextile which includes all properties contained in the project specifications measured using the appropriate test methods.
5. Written certification that minimum average roll values given in the specification are guaranteed by the Manufacturer.
6. For non-woven geotextiles, written certification that the Manufacturer has continuously inspected the geotextile for the presence of needles and found the geotextile to be needle free.
7. Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, sampling procedures and results of quality control tests. At a minimum, results shall be given for:

    a. Mass per unit area
    b. Grab strength
    c. Trapezoidal tear strength
    d. Burst strength
    e. Puncture strength
    f. Thickness

    Quality control tests shall be performed in accordance with the frequency and test methods identified in the project Specifications.

The Manufacturer shall identify all rolls of geotextiles with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The Geosynthetic CQA Consultant shall review these documents and shall report any discrepancies with the above requirements to the Construction Manager. The Geosynthetic CQA Consultant shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.
2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.
3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.
4. Roll packages are appropriately labeled.
5. Certified minimum average roll properties meet the project specifications.

3.2 CONFORMANCE TESTING

Upon delivery of the rolls of geotextiles, the Geosynthetic CQA Consultant shall ensure that conformance test samples are obtained for the geotextile. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance to ensure conformance to the project specifications.

At a minimum, the following conformance tests shall generally be performed on geotextiles:

1. Mass per unit area
2. Grab strength
3. Trapezoidal tear strength
4. Burst strength
5. Puncture strength
6. Thickness

These conformance tests shall be performed in accordance with the test methods specified in the project specifications. Other conformance tests may be required by the project specifications.

3.2.1 Sampling Procedures

The rolls to be sampled shall be selected by the Geosynthetic CQA Consultant. Samples shall be taken across the entire width of the roll and shall not include the first complete revolution of fabric on the roll. Samples shall not be taken from any portion of a roll which has been subjected to excess pressure or stretching. Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic CQA Consultant shall mark the machine direction on the samples with an arrow. All lots of material and the particular test sample that represents each lot should be defined before the samples are taken.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic CQA Consultant based on a review of all roll information including quality control documentation and manufacturing records.

3.2.2 Test Results

All conformance test results shall be reviewed by the Geosynthetic CQA Consultant prior to the deployment of the geotextile. The Geosynthetic CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the Construction Manager. The Geosynthetic CQA Consultant shall be responsible for checking that all test results meet or exceed the property values listed in the project Specifications. Based upon the recommendations of the Geosynthetic CQA Consultant, the Construction Manager shall accept or reject the geotextile.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested with a technical representative of the Manufacturer present during the testing. This retesting shall be done at the expense of the Manufacturer. Alternatively, the Manufacturer may have the sample retested at two different Solutia approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Construction Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out of specification and rejected. Alternatively, at the option of the Construction Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out of specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

3.3 GEOTEXTILE DEPLOYMENT

During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions. Geotextile rolls shall be shipped and stored in relatively opaque and watertight wrappings. Wrappings shall be removed shortly before deployment.

The Geosynthetic CQA Consultant shall observe rolls upon delivery at the site and any deviation from the above requirements shall be reported to the Construction Manager.

The Installer shall handle all geotextiles in such a manner as to ensure they are not damaged in any way, and the following shall be complied with:

1. On slopes, the geotextiles shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geotextile sheet in tension.
2. In the presence of wind, all geotextiles shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.
3. Geotextiles shall be cut using a geotextile cutter (hook blade) only. If in place, special care shall be taken to protect other materials from damage which could be caused by the cutting of the geotextiles.
4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.
5. During placement of geotextiles, care shall be taken not to entrap, in or beneath the geotextile, stones, excessive dust, or moisture that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming.
6. A visual examination of the geotextile shall be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects, such as needles, are present.

The Geosynthetic CQA Consultant shall note any noncompliance and report it to the Construction Manager.

3.4 SEAMING PROCEDURES

On slopes steeper than 10 (horizontal):1 (vertical), all geotextiles shall be continuously sewn (i.e., spot sewing is not allowed). Geotextiles shall be overlapped a minimum of 3 inches (75 mm) prior to seaming. In general, no horizontal seam shall be allowed on side slopes (i.e., seams shall be along, not across, the slope), except as part of a patch.

On bottoms and slopes shallower than 10 (horizontal):1 (vertical), geotextiles shall be seamed as indicated above (preferred), or thermally bonded with the written approval of the Construction Manager.

The Installer shall pay particular attention at seams to ensure that no earth cover material could be inadvertently inserted beneath the geotextile.

Any sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile. Sewing shall be done using machinery and stitch types specified in the project specifications or as approved in writing by the Construction Manager and the Geosynthetic CQA Consultant.

3.5 DEFECTS AND REPAIRS

Any holes or tears in the geotextile shall be repaired as follows:

1. On slopes, a patch made from the same geotextile shall be sewn into place in accordance with the project specifications. Should any tear exceed 10% of the width of the roll, that roll shall be removed from the slope and replaced.

2. Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile.

3. The Geosynthetic CQA Consultant shall observe any repair and report any noncompliance with the above requirements in writing to the Construction Manager.

3.6 GEOTEXTILE PROTECTION

All soil materials located on top of a geotextile shall be deployed in such a manner as to ensure:

1. The geotextile and underlying lining materials are not damaged.
2. Minimal slippage of the geotextile on underlying layers occurs.
3. No excess tensile stresses occur in the geotextile.

Any noncompliance shall be noted by the Geosynthetic CQA Consultant and reported to the Construction Manager. If portions of the geotextile are exposed, the Geosynthetic CQA Consultant may periodically place two (or more, at his discretion) marks on the geotextile 10 ft (3 m) apart along the slope and measure the elongation of the geotextile during the placement of soil. This data shall be reported to the Construction Manager.

4.1 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geonet, the Manufacturer or Installer shall provide the Construction Manager with the following information:

1. The origin (resin supplier's name and resin production plant), identification (brand name and number), and production date of the resin.
2. Copies of the quality control certificates issued by the resin supplier.
3. Reports on tests conducted by the Manufacturer to verify that the quality of the resin used to manufacture the geonet meets the Specifications.
4. Reports on quality control tests conducted by the Manufacturer to verify that the geonet manufactured for the project meets the project specifications.
5. A list of the materials which comprise the geonet expressed in the following categories as percent by weight: polyethylene, carbon black, other additives.
6. A specification for the geonet which includes all properties contained in the Specifications measured using the appropriate test methods.
7. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.
8. Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, sampling procedures and results of quality control tests. At a minimum, results shall be given for:

   a. Density
   b. Mass per unit area
   c. Thickness
   d. Carbon black content
   e. Transmissivity

   Quality control tests shall be performed in accordance with the frequency and test methods identified in the Specifications.

The Manufacturer shall identify all rolls of geonets with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The Geosynthetic CQA Consultant shall review these documents and shall report any discrepancies with the above requirements to the Construction Manager. The Geosynthetic CQA Consultant shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.
2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.
3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.
4. Roll packages are appropriately labeled.
5. Certified minimum properties meet the Specifications.

4.2 CONFORMANCE TESTING

Upon delivery of the rolls of geonet, the Geosynthetic CQA Consultant shall ensure that conformance test samples are obtained for the geonet. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance to the Specifications.

At a minimum, the following tests shall be performed:

1. Density
2. Mass per unit area
3. Thickness
4. Interface friction between smooth geomembrane/geonet and textured geomembrane/geonet.
5. Transmissivity

These conformance tests shall be performed in accordance with the test methods specified in the Solutia specifications. Other conformance tests required by the project specifications shall be performed. Interface friction test results shall be submitted for review and approval within 30 days of contract award.

4.2.1 Sampling Procedures

The rolls to be sampled shall be selected by the Geosynthetic CQA Consultant. Samples shall be taken across the entire width of the roll and shall not include the first 3 ft (1 m). Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic CQA Consultant shall mark the machine direction on the samples with an arrow.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic CQA Consultant based on a review of all roll information including quality control documentation and manufacturing records.

4.2.2 Test Results

All conformance test results shall be reviewed and by the Geosynthetic CQA Consultant prior to the deployment of the geonet. The Geosynthetic CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the Construction Manager. The Geosynthetic CQA Consultant shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications. Based upon the recommendations of the Geosynthetic CQA Consultant the Construction Manger will accept or reject the geonet.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. This retesting shall be done at the expense of the Manufacturer. Alternatively, the Manufacturer may have the sample retested at two different Solutia approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Construction Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out of specification and rejected. Alternatively, at the option of the Construction Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out of specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

4.3 GEONET DEPLOYMENT

The Geosynthetic CQA Consultant shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Construction Manager.

Geonet cleanliness is essential to its performance. Therefore, the geonet rolls should be protected against dust and dirt during shipment and storage.

The Geosynthetic CQA Consultant shall verify that the geonet is free of dirt and dust prior to installation. The Geosynthetic CQA Consultant shall report the outcome of this verification to the Construction Manager, and if the geonet is judged dirty or dusty, it shall be washed by the

Installer prior to installation. Washing operations shall be observed by the Geosynthetic CQA Consultant and improper washing operations shall be reported to the Construction Manager.

The Installer shall handle all geonet in such a manner as to ensure that it is not damaged in any way, and the following shall be complied with:

1. On slopes, the geonet shall be secured and rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet shall be positioned by hand after being unrolled to minimize wrinkles.
2. In the presence of wind, all geonet shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.
3. Unless otherwise specified, geonet shall not be welded to geomembrane.
4. Geonet shall only be cut using scissors or other cutting tools approved by the Construction Manager that will not damage the underlying geosynthetics. Care shall be taken not to leave tools in the geonet.
5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geonet.
6. During placement of geonet, care shall be taken not to entrap in the geonet dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geonet, it should be hosed clean prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags, to prevent rupture or damage of the sandbag.

The Geosynthetic CQA Consultant shall note any noncompliance and report it to the Construction Manager.

4.4 SEAMS AND OVERLAPS

Adjacent geonet shall be joined according to construction drawings and specifications. At a minimum, the following requirements shall be met:

1. Adjacent rolls shall be overlapped by at least 4 inches (100 mm).
2. Overlaps shall be secured by tying.
3. Tying can be achieved by plastic fasteners or polymer braid. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.
4. Tying shall be every 5 ft (1.5 m) along the slope, every 6 inches (0.15 m) in the anchor trench, and every 6 inches (0.15 m) along end-to-end seams on the base of the landfill.
5. In general, no horizontal seams shall be allowed on side slopes.

6. In the corners of the side slopes of rectangular landfills, where overlaps between perpendicular geonet strips are required, an extra layer of geonet shall be unrolled along the slope, on top of the previously installed geonet, from top to bottom of the slope.
7. When more than one layer of geonet is installed, joints shall be staggered.

The Geosynthetic CQA Consultant shall note any noncompliance and report it to the Construction Manager.

When several layers of geonet are stacked, care shall be taken to prevent strands of one layer from penetrating the channels of the next layer, thereby significantly reducing the transmissivity. This cannot happen if stacked geonet are placed in the same direction.

4.5 DEFECTS AND REPAIRS

Any holes or tears in the geonet shall be repaired by placing a patch extending 1 ft (0.3 m) beyond the edges of the hole or tear. The patch shall be secured to the original geonet by tying every 6 inches (0.15 m). Tying devices shall be as indicated in the Specifications. If the hole or tear width across the roll is more than 50% of the width of the roll, the damaged area shall be repaired as follows:

1. On the base of the landfill, the damaged area shall be cut out and the two portions of the geonet shall be joined as indicated in the Specifications.
2. On sideslopes, the damaged geonet shall be removed and replaced.

The Geosynthetic CQA Consultant shall observe any repair and report any noncompliance with the above requirements in writing to the Construction Manager.

4.6 GEONET PROTECTION

Soil should never be placed in direct contact with geonet. Soil materials near the geonet shall be placed in such a manner as to ensure:

1. The geonet and underlying lining materials are not damaged.
2. Minimal slippage of the geonet on underlying layers occurs.
3. No excess tensile stresses occur in the geonet.

Any noncompliance shall be noted by the Geosynthetic CQA Consultant and reported to the Construction Manager.

5.1 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geogrid, the Manufacturer or Installer shall provide the Construction Manager with the following information:

1. The origin (resin supplier's name and resin production plant), identification (brand name and number), and production date of the resin.
2. Copies of the quality control certificates issued by the resin supplier.
3. Reports on tests conducted by the Manufacturer to verify that the quality of the resin used to manufacture the geogrid meets the Specifications.
4. Reports on quality control tests conducted by the Manufacturer to verify that the geogrid manufactured for the project meets the project specifications.
5. A list of the materials which comprise the geogrid, expressed in the following categories as percent by weight: polyethylene, carbon black, other additives.
6. A specification for the geogrid which includes all properties contained in the project specifications measured using the appropriate test methods.
7. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.
8. Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificate shall include roll identification numbers, sampling procedures, and results of quality control tests. At a minimum, results shall be given for:

    a. Mass per unit area

    b. Measurement of spacing between strands

    c. Wide strip tensile strength

    d. Node strength

Quality control tests shall be performed in accordance with the frequency and test methods specified in the Specifications.

The Manufacturer shall identify all rolls of geogrids with the following:

a. Manufacturer's name

b. Product identification

c. Roll number

d. Roll dimensions

The Geosynthetic CQA Consultant shall review these documents and shall report any discrepancies with the above requirements to the Construction Manager. The Geosynthetic CQA Consultant shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.
2. Measurement of properties by the Manufacturer are properly documented and that the test methods used are acceptable.
3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.
4. Roll packages are appropriately labeled.
5. Certified minimum properties meet the Specifications.

5.2 CONFORMANCE TESTING

Upon delivery of the rolls of geogrid, the Geosynthetic CQA Consultant shall ensure that conformance test samples are obtained for the geogrid. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance to the project specifications.

At a minimum, the following conformance tests shall be performed on geogrid:

1. Mass per unit area
2. Measurement of spacing between strands
3. Wide strip tensile strength
4. Node strength

These conformance tests shall be performed in accordance with the test methods specified in the project specifications. Other conformance tests may be required by the project specifications.

5.2.1 Sampling Procedures

The rolls to be sampled shall be selected by the Geosynthetic CQA Consultant. Samples shall be taken across the entire width of the roll and shall not include the first 3 ft (1 m). Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic CQA Consultant shall mark the machine direction on the samples with an arrow.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic CQA Consultant based on a review of all roll information including quality control documentation and manufacturing records.

5.2.2 Test Results

All conformance test results must be reviewed and accepted or rejected by the Geosynthetic CQA Consultant prior to the deployment of the geogrid.

The Geosynthetic CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the Construction Manager. The Geosynthetic CQA Consultant shall be responsible for checking that all test results meet or exceed the minimum property values listed in project specifications.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. This retesting shall be done at the expense of the Manufacturer. Alternatively, the Manufacturer may have the sample retested at two different Solutia approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Construction Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test shall be considered out of specification and rejected. Alternatively, at the option of the Construction Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out of specification material additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

5.3 GEOGRID DEPLOYMENT

The Installer shall handle all geogrid in such a manner as to ensure it is not damaged in any way, and the following shall be complied with:

1. On slopes, the geogrid shall be secured and rolled down the slope in such a manner as to continually keep the geogrid in tension.
2. In the presence of wind, all geogrids shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.
3. Geogrid shall be cut using scissors only. If in place, special care shall be taken to protect other materials from damage which could be caused by the cutting of the geogrid.
4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geogrid.

The Geosynthetic CQA Consultant shall note any noncompliance and report it to the Construction Manager.

5.4 SEAMS AND OVERLAPS

The geogrid, where used, shall be placed in continuous pieces downslope. No lateral joining is required. Edge to edge placement shall be sufficient.

Where geogrid is joined end to end, a splice approved by the manufacturer shall be used. The splice shall not have any metallic components.

5.5 REPAIRS

Any damaged roll of geogrid shall be discarded. No repairs shall be allowed.

5.6 SOIL MATERIALS PLACEMENT

All soil materials located on top of a geogrid shall be deployed in such a manner as to ensure:

1. The geogrid and underlying materials are not damaged.
2. Minimal slippage of the geogrid on underlying layers occurs.

Any noncompliance shall be noted by the Geosynthetic CQA Consultant and reported to the Construction Manager.

6.1 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geosynthetic clay liner (GCL), the Manufacturer or Installer shall provide the Construction Manager with the following information:

1. The origin (supplier's name and production plant), identification (brand name and number), and production date.
2. Copies of the quality control certificates issued by the supplier.
3. Reports on tests conducted by the Manufacturer to verify that the quality used to manufacture the GCL meets the Specifications.
4. Reports on quality control tests conducted by the Manufacturer to verify that the GCL manufactured for the project meets the project specifications.
5. A specification for the GCL which includes all properties contained in the Specifications measured using the appropriate test methods.
6. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.
7. Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, sampling procedures and results of quality control tests. At a minimum, results shall be given for:

    a. Swell Index

    b. Mass per unit area

    c. Thickness

    d. Grab Tensile Strength

    e. Permeability

    Quality control tests shall be performed in accordance with the frequency and test methods identified in the Specifications.

The Manufacturer shall identify all rolls of GCLs with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The Geosynthetic CQA Consultant shall review these documents and shall report any discrepancies with the above requirements to the Construction Manager. The Geosynthetic CQA Consultant shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.
2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.
3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.
4. Roll packages are appropriately labeled.
5. Certified minimum properties meet the Specifications.

6.2 CONFORMANCE TESTING

Upon delivery of the rolls of GCL, the Geosynthetic CQA Consultant shall ensure that conformance test samples are obtained for the GCL. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance to the Specifications.

At a minimum, the following tests shall be performed:

1. Swell Index
2. Mass per unit area
3. Thickness
4. Permeability
5. Interface friction between geosynthetic clay liner/soil as well as the textured geomembrane/geosynthetic clay liner conformance test identified in Section 2.2.

These conformance tests shall be performed in accordance with the test methods specified in the Solutia specifications. Other conformance tests required by the project specifications shall be performed.

6.2.1 Sampling Procedures

The rolls to be sampled shall be selected by the Geosynthetic CQA Consultant. Samples shall be taken across the entire width of the roll and shall not include the first 3 ft (1 m). Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic CQA Consultant shall mark the machine direction on the samples with an arrow.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic CQA Consultant based on a review of all roll information including quality control documentation and manufacturing records.

6.2.2 Test Results

All conformance test results shall be reviewed and by the Geosynthetic CQA Consultant prior to the deployment of the GCL. The Geosynthetic CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the Construction Manager. The Geosynthetic CQA Consultant shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications. Based upon the recommendations of the Geosynthetic CQA Consultant the Construction Manger will accept or reject the GCL.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. This retesting shall be done at the expense of the Manufacturer. Alternatively, the Manufacturer may have the sample retested at two different Solutia approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Construction Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out of specification and rejected. Alternatively, at the option of the Construction Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out of specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

6.3 GCL DEPLOYMENT

The Geosynthetic CQA Consultant shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Construction Manager.

The Installer shall handle all GCL in such a manner as to ensure that it is not damaged in any way, and the following shall be complied with:

1. On slopes, the GCL shall be secured and rolled down the slope in such a manner as to continually keep the GCL sheet in tension. If necessary, the GCL shall be positioned by hand after being unrolled to minimize wrinkles.
2. In the presence of wind, all GCL shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.

3. Unless otherwise specified, GCL shall not be welded to geomembrane.
4. GCL shall only be cut using scissors or other cutting tools approved by the Construction Manager that will not damage the underlying geosynthetics. Care shall be taken not to leave tools in the GCL.
5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the GCL.
6. During placement of GCL, care shall be taken not to entrap dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. In this regard, care shall be taken with the handling of sandbags, to prevent rupture or damage of the sandbag.

The Geosynthetic CQA Consultant shall note any noncompliance and report it to the Construction Manager.

6.4 SEAMS AND OVERLAPS

Adjacent GCL shall be joined according to construction drawings and specifications. At a minimum, the following requirements shall be met:

1. Adjacent rolls shall be overlapped by at least 4 inches (100 mm).
2. In general, no horizontal seams shall be allowed on side slopes.
3. In the corners of the side slopes of rectangular landfills, where overlaps between perpendicular GCL strips are required, an extra layer of GCL shall be unrolled along the slope, on top of the previously installed GCL, from top to bottom of the slope.
4. When more than one layer of GCL is installed, joints shall be staggered.

The Geosynthetic CQA Consultant shall note any noncompliance and report it to the Construction Manager.

6.5 DEFECTS AND REPAIRS

Any holes or tears in the GCL shall be repaired by placing a patch extending 1 ft (0.3 m) beyond the edges of the hole or tear. If the hole or tear width across the roll is more than 50% of the width of the roll, the damaged area shall be repaired as follows:

1. On the base of the landfill, the damaged area shall be cut out and the two portions of the GCL shall be joined as indicated in the Specifications.
2. On sideslopes, the damaged GCL shall be removed and replaced.

The Geosynthetic CQA Consultant shall observe any repair and report any noncompliance with the above requirements in writing to the Construction Manager.

An effective CQA Manual depends largely on identification of all construction activities that shall be monitored, and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The Geosynthetic CQA Consultant shall document that all requirements in the geosynthetic portions of the project have been addressed and satisfied.

The Geosynthetic CQA Consultant shall provide the Construction Manager with signed descriptive remarks, data sheets, and checklists to verify that all monitoring activities have been carried out. The Geosynthetic CQA Consultant shall also maintain at the job site a complete file of all documents which comprise the CQA Manual, including Plans and Specifications, checklists, test procedures, daily logs, and other pertinent documents.

8.1 DAILY REPORTS

Each on-site representative of the Geosynthetic CQA Consultant shall complete a daily report and/or logs on prescribed forms, outlining all monitoring activities for that day. The precise areas, panel numbers, seams completed and approved, and measures taken to protect unfinished areas overnight shall be identified. Failed seams or other panel areas requiring remedial action shall be identified with regard to nature of action, required repair, and precise location. Repairs completed must also be identified. Any problems or concerns with regard to operations on site should also be noted. Any matters requiring action by the Construction Manager shall be identified. The report shall include a summary of the quantities of all geosynthetics installed that day.

This report must be completed daily, and submitted to the Construction Manager at the beginning of the work day following the report date.

8.2 DESTRUCTIVE TESTING REPORTS

The destructive test reports from all sources shall be collated by the Geosynthetic CQA Consultant. This includes field tests, Installers laboratory tests (if performed), and Geosynthetic QAL tests. A summary list of test sample pass/fail results shall be prepared by the Geosynthetic CQA Consultant on an ongoing basis, and submitted with the weekly progress reports.

8.3 PROGRESS REPORTS

Progress reports shall be prepared by the Geosynthetic CQA Consultant and submitted to the Construction Manager. These reports shall be submitted every week, starting the first Friday of geosynthetics deployment on site. This report shall include: an overview of progress to date; an outline of any changes made to the Plans or Specifications, any problems or deficiencies in installation at the site, and an outline of any action taken to remedy the situation(s); a summary of weather conditions; and a brief description of activities anticipated for the next reporting period.

All geosynthetics CQA Consultant daily reports for the period should be appended to each progress report.

8.4 AS-BUILT DRAWINGS

As-built drawings shall be prepared by the Geosynthetic CQA Consultant. The as-built drawings shall include, at a minimum, the following information for geomembranes:

1. Dimensions of all geomembrane field panels.
2. Location, as accurate as possible, of each panel relative to the site survey grid (furnished by the Construction Manager).
3. Identification of all seams and panels with appropriate numbers or identification codes (see Section 4.5.1).
4. Location of all patches and repairs.
5. Location of all destructive testing samples.

Information collected during installation of the geosynthetic materials shall be compiled in the field while construction is in progress. Upon completion of a layer or component of the landfill (e.g. primary geomembrane liner) a draft copy of the compiled as built drawing and construction data shall be submitted to the Construction Manager.

The as-built drawings shall illustrate each layer of geomembrane, and, if necessary, another drawing shall identify problems or unusual conditions of the geotextile or geonet layers. In addition, applicable cross-sections shall show layouts of geonets, geotextiles or geogrids in sump areas or any other areas which are unusual or differ from the design Plans.

8.5 FINAL CERTIFICATION REPORT

A final certification report shall be submitted upon completion of the work. This report shall summarize the activities of the project, and document all aspects of the quality assurance program performed.

The final certification report shall include, at a minimum, the following information:

1. Parties and personnel involved with the project
2. Scope of work
3. Outline of project
4. Quality assurance methods
5. Test results (conformance, destructive and non-destructive, including laboratory tests)
6. Certification, sealed and signed by a registered Professional Engineer
7. As-built drawings, sealed and signed by a registered professional engineer

The Geosynthetic CQA Consultant shall certify in the report that the installation has proceeded in accordance with the project Plans and Specifications except as noted to the Construction Manager. A recommended outline for the final certification report is given in Exhibit 2-1. At the direction of the Construction Manager this final certification report may be combined with the certification report for the soil components of the lining and final cover system.

TABLES

TABLE 1

GEOSYNTHETIC MATERIAL PROPERTIES
SAUGET AREA 1 TSCA LANDFILL
SOLUTIA INC.
CAHOKIA, ILLINOIS

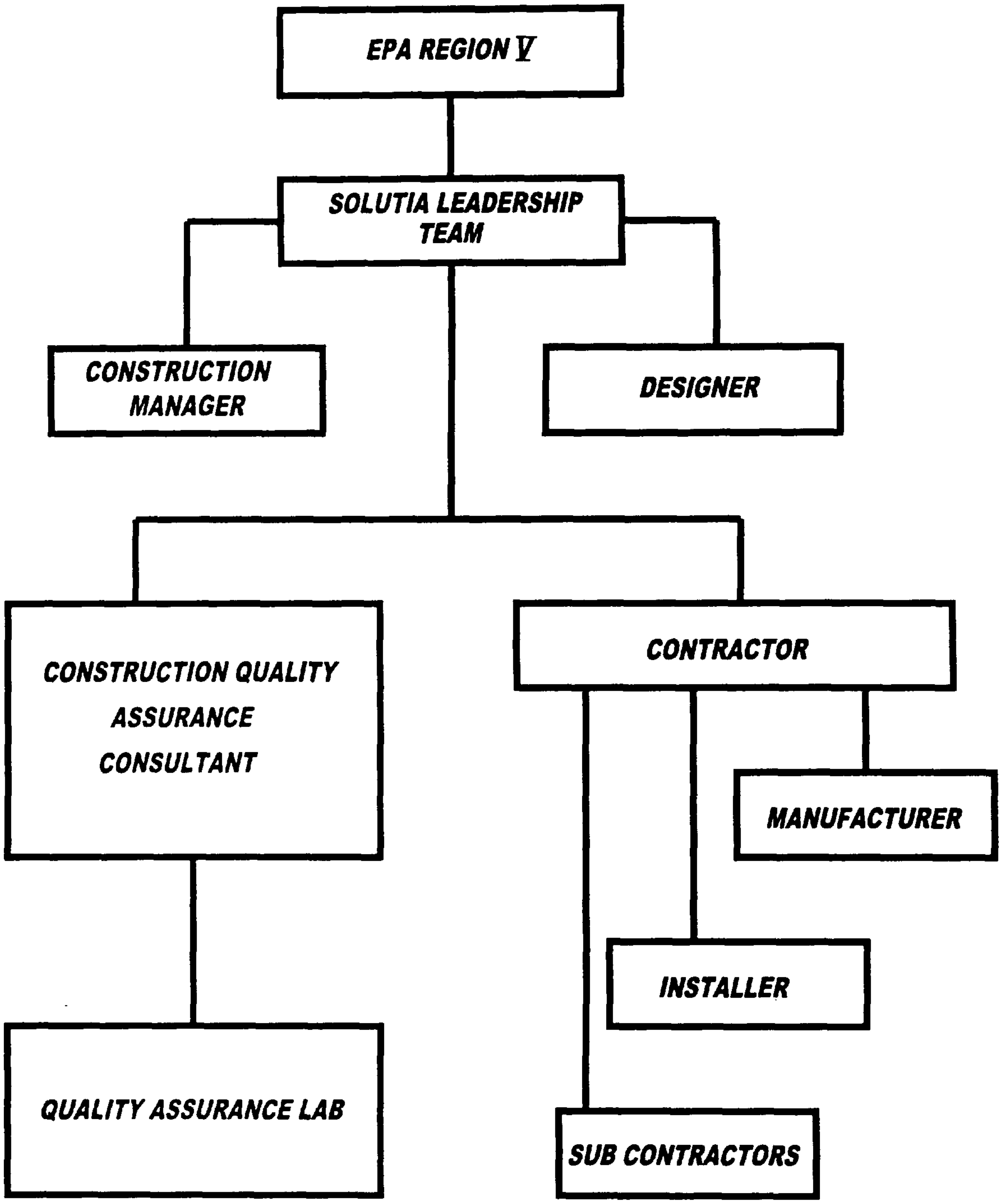
Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
HDPE Geomembrane					
Smooth	Liner Thickness, mils (nominal)	ASTM D5199	60	mils	Per Roll
	Density (g/cc)	ASTM D1505-A	0.94	g/cc	200,00 lbs
	Tensile Properties (min. aveg.)	ASTM D 638 Type IV Dumb-bell @ 2 ipm			20,000 lbs
	1. Tensile Strength @ Yield (ppi)	(2.0" Gauge Length)	126	lbs/in.	
	2. Tensile Strength @ Break (ppi)	(NSF 54, Mod.)	228	lbs/in.	
	3. Elongation @ Yield (%)		12	%	
	4. Elongation @ Break (%)		700	%	
	Tear Resistance (min. ave.)	ASTM D 1004 Die C	42	---	45,000 lbs
	Dimensional Stability % Change Each Direction	ASTM D 1204 212 °F 1 hr	± 2		
	Stress Crack Resistance (hrs)	ASTM D 5397	200	hrs	Per Batch
	Puncture Resistance (min. aveg.)	ASTM 4833	108	lbs	45,000 lbs
	Carbon Black Content (%)	ASTM D 1603	2	%	20,000 lbs
	Carbon Black Dispersion	ASTM D 5596	A1, A2 and B1		45,000 lbs
	Oxidative Induction Time (OIT)				200,000 lbs
	(a) Standard OIT (min. aveg.) -or-	ASTM D 3895	100	min.	
	(b) High Pressure OIT (min. aveg.)	ASTM D 5885	400	min.	

Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
	UV Resistance	GM 11			Per Batch
	(a) Standard OIT (min. aveg.)	ASTM D 3895	Not Recommend	N/A	
	-or-				
	(b) High Pressure OIT (min. aveg.) - % retained after 1600 hrs	ASTM D 5885	50	%	
<u>HDPE Geomembrane</u>					
<u>Textured</u>	Liner Thickness, mils (nominal)	ASTM D 5199	60	mils	Per Roll
	Density (g/cc)	ASTM D 1505-A	0.94	g/cc	200,000 lbs
	Asperity Height	GM 12	10	mils	Per Roll
	Tensile Properties (min. aveg.)	ASTM D 638 Type IV Dumb-bell @ 2 ipm			
	1. Tensile Strength @ Yield (ppi)	(2.0" Gauge Length)	126	lbs/in.	---
	2. Tensile Strength @ Break (ppi)	(NSF 54, Mod.)	90	lbs/in.	---
	3. Elongation @ Yield (%)		12	%	---
	4. Elongation @ Break (%)		100	%	---
	Tear Resistance (min. aveg.)	ASTM D1004 Die C	42 lbs	lbs	
	Dimensional Stability % Change Each Direction	ASTM D 1204 212 °F 1 hr	± 2	---	
	Stress Crack Resistance (hrs)	ASTM D 5397	200	hrs	
	Puncture Resistance (min. aveg.)	ASTM 4833	90	lbs	
	Carbon Black Content (%)	ASTM D 1603	2	hrs	
	Carbon Black Dispersion	ASTM D 5596	A1, A2 and B1	%	
	Oxidative Induction Time (OIT)				
	(a) Standard OIT (min. aveg.)	ASTM D 3895	100	min.	
	-or-				
	(b) High Pressure OIT (min. aveg.)	ASTM D 5885	400	min.	

Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
	UV Resistance	GM 11			Per Batch
	(a) Standard OIT (min. ave.) -or-	ASTM D 3895	Not Recommend	N/A	
	(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs	ASTM D 5885	50	%	
Geotextile					
	Mass per Area	ASTM D 5261	16	oz/yd^2	
	Grab Strength	ASTM D 4632	380	lbs	
	Elongation	ASTM D 4632	60	%	
	AOS	ASTM D 4751	100	U.S. Sieve	
	Permittivity	ASTM D 4491	0.7	sec^{-1}	
	Trapezoidal Tear Strength	ASTM D 4533	145	lbs	
	Burst Strength	ASTM D 3786	750	psi	
	Puncture Strength	ASTM D 4833	240	lbs	
Geonet					
	Density	ASTM D 792 or D 1505	0.90 min.	g/cu cm	1 per batch
	Thickness	ASTM D 5199	200 min.	mils	4 per roll
	Melt Flow Index	ASTM D 1238	1.0 max.	g/10 min.	1 per batch
	Carbon Black Content	ASTM D 1603	2-3 range	%	1 per batch
	Tensile Strength at Break:				
	• Machine Direction	ASTM D 4595	360 (min.)	lbs/ ft	1 / 40,000 ft^2
	• Cross Direction	ASTM D 4595	200 (min.)	lbs/ ft	1 / 40,000 ft^2
	Transmissivity	ASTM D 4716	1.0	cm/sec	1 per shift

Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
Geosynthetic Clay Liner Unreinforced	Bentonite Swell Index	ASTM D 5890	24	mL/2g min.	1 per 50 tonnes
	Bentonite Fluid Loss	ASTM D 5890	18	mL max.	1 per 50 tonnes
	Bentonite Mass/Area	ASTM D 5993	0.75	lb/ft^2	40,000 ft^2
	GCL Grab Strength	ASTM D 4632	75	lbs	200,000 ft^2
	GCL Peel Strength	ASTM D 4632	N/A	N/A	N/A
	GCL Index Flux	ASTM D 5887	$1x10^{-8}$	$m^3/m^2/sec$	Weekly
	GCL Permeability	ASTM D5084	$5x10^{-9}$	cm/s	Weekly
	GCL Hydrated Internal Shear Strength	ASTM D 5321	50	psf	Periodic
Reinforced	Bentonite Swell Index	ASTM D 5890	24	mL/2g min.	1 per 50 tonnes
	Bentonite Fluid Loss	ASTM D 5890	18	mL max.	1 per 50 tonnes
	Bentonite Mass/Area	ASTM D 5993	0.75	lb/ft^2	40,000 ft^2
	GCL Grab Strength	ASTM D 4632	90	lbs	200,000 ft^2
	GCL Peel Strength	ASTM D 4632	15	lbs	40,000 ft^2
	GCL Index Flux	ASTM D 5887	$1x10^{-8}$	$m^3/m^2/sec$	Weekly
	GCL Permeability	ASTM D5084	$5x10^{-9}$	cm/s	Weekly
	GCL Hydrated Internal Shear Strength	ASTM D 5321	500	psf	Periodic

FIGURES



PREPARED FOR: SOLUTIA	Drawn:	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE 1-1
URSGWC JOB NUMBER: C100003899.00	Design:		
URS Greiner Woodward Clyde A Division of URS Corporation 7650 W. Courtney Campbell Causeway Tampa, Florida 33607-1462 Tel: 813.286.1711 Fax: 813.287.8591	Checked: G. WANTLAND	DRAWING TITLE CONSTRUCTION QUALITY ASSURANCE PROTECT ORGANIZATION CHART	
	Date: OCT. 30, 2000		

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EXHIBITS

EXHIBIT 1-1

RESOLUTION MEETING AGENDA

SAUGET AREA 1
SOLUTIA INC.
CAHOKIA, ILLINOIS

1. Introductions

   A. Assign Minute Taker

   B. Identify Parties

      1. Construction Manager
      2. Designer
      3. Geosynthetic Quality Assurance Consultant
      4. Solutia representative
      5. Others

2. Distribution of Documents

   A. Design and Construction Drawings
   B. Specifications
   C. Construction Quality Assurance (CQA) Manuals
   D. Permit Documents

3. Review Construction Plans and Specifications

4. Review Geosynthetic CQA Manual

5. Tour Project Site

6. Contract Administration and Construction Issues

7. Define Lines of Communication

8. Project Deliverables

9. Schedule

EXHIBIT 1-2

PRE-CONSTRUCTION MEETING AGENDA

SAUGET AREA 1
SOLUTIA INC.
CAHOKIA, ILLINOIS

1. Introductions

   A. Assign Minute Taker

   B. Identify Parties

      1. Construction Manager
      2. Construction Contractor
      3. Geosynthetic Construction Quality Assurance Consultant
      4. Installer
      5. Designer
      6. Solutia Representative

2. Distribution of Documents

   A. Construction Plans and Specifications

   B. Geosynthetic Panel Layout

   C. Geosynthetic Construction Quality Assurance Manual

3. Lines of Communication

   A. Reporting Methods

   B. Progress Meetings

   C. Procedures for Approving Design Clarifications and Changes During Construction

4. Tour Project Site

5. Site Requirements

   A. Safety Rules

   B. Site Rules

   C. Work Schedule

   D. Storage of Materials

   E. Available Facilities

EXHIBIT 1-2

PRE-CONSTRUCTION MEETING AGENDA

SAUGET AREA 1
SOLUTIA INC.
CAHOKIA, ILLINOIS
(Continued)

6. Construction Issues
   A. Scope of Work
   B. Review Plans and Specifications
      1. Design and Construction Requirements
      2. Geosynthetic Panel Layout
   C. Review Construction Procedures
      1. Proposed Construction Sequencing
      2. Equipment
   D. Review Construction Schedule
   E. Review Procedures for Preparing and Approving Change Orders
7. Discuss Construction Quality Assurance Plan
   A. Soils
   B. Geosynthetics
   C. Structural Systems (e.g., risers, piping, etc.)
8. Project Deliverables
   A. Responsibilities
      1. Construction Manager
      2. Designer
      3. Installer
      4. Geosynthetic Construction Quality Assurance Consultant
   B. Distribution of Deliverables
   C. Approval Procedures

EXHIBIT 2-1

FINAL CONSTRUCTION QUALITY ASSURANCE CERTIFICATION REPORT GENERAL OUTLINE

SAUGET AREA 1
SOLUTIA INC.
CAHOKIA, ILLINOIS

1. Introduction
   - Purpose
   - Scope
   - Unit Description
2. Project Specifications
   - Scope
   - Design Changes
3. Quality Assurance Plan
   - Scope
   - Project-Specific Addenda
4. Quality Assurance Work Performed
   - Weather Constraints
   - Conformance Testing
   - Visual Monitoring
   - Nondestructive Testing
   - Destructive Testing
   - Repairs
5. Summary and Conclusions
6. Project Certification
7. Appendices
   - Geosynthetic and/or Soils QAC Personnel
   - Contractor Personnel
   - Quality Assurance Plan (QAP) and Specification Modifications
   - Design Change Forms

EXHIBIT 2-1

FINAL CONSTRUCTION QUALITY ASSURANCE CERTIFICATION REPORT
GENERAL OUTLINE

SAUGET AREA 1
SOLUTIA INC.
CAHOKIA, ILLINOIS
(Continued)

- Earthwork Testing Records (if required)
- Conformance Testing Records
- Manufacturer Quality Control Records
- Quality Assurance Reports
- Subgrade Acceptance Certificates Panel Placement Records
- Destructive Seam Testing Records Destructive Seam Testing Records Repairs
- As-Built Drawings

APPENDIX A

EXAMPLES OF GEOSYNTHETIC QUALITY ASSURANCE DOCUMENTATION

PANEL PLACEMENT FORM

PROJECT:	QUALITY ASSURANCE MONITOR:	MATERIAL DESCRIPTION:

DATE/ TIME	PANEL NUMBER	ROLL NUMBER	PANEL LENGTH	PANEL WIDTH	PANEL LOCATION	PANEL CONDITION- VISUAL INSPECTION	COMMENTS

TRIAL WELD INFORMATION

PROJECT:	QUALITY ASSURANCE MONITOR:	MATERIAL DESCRIPTION:

					EXTRUSION WELDS		FUSION WELDS					
Date/ Time	Weather/ Winds	Ambient Temp.	Seamer Initials	Machine Number	Barrel Temp. Set/PYRO	Preheat Temp. Set/PYRO	Wedge Temp. Set/PYRO	Measured Speed (ft/min)	Wheel Tension Setting	Peel Values (lbs/inch)	Pass/Fail	Comments

PANEL SEAMING CHECKLIST

PROJECT:	QUALITY ASSURANCE MONITOR:	MATERIAL DESCRIPTION:

DATE/ TIME	WEATHER/ WINDS	AMBIENT TEMP.	SEAMER INITIALS	MACHINE NUMBER	SEAM TYPE	SEAM NUMBER	PANEL NUMBERS	SEAM LENGTH	TEMP. SETTING	MACHINE SPEED	COMMENTS

NON-DESTRUCTIVE SEAM TEST LOG

PROJECT:	QUALITY ASSURANCE MONITOR:	MATERIAL DESCRIPTION:

DATE/ TIME	SEAM NUMBER	TESTER INITIALS	AIR TESTING					PASS/ FAIL	VACCUM BOX PASS/FAIL	COMMENTS
			PRESSURE (PSI)			TIME				
			START	END	DROP	START	END			

DESTRUCTIVE SEAM TEST LOG

PROJECT:	QUALITY ASSURANCE MONITOR:	MATERIAL DESCRIPTION:

DATE/ TIME	SAMPLE I.D.	SEAM NUMBER	TENS NUMBER	OPERATOR INTIALS	FIELD TENSIOMETER PEEL VALUES (LBS/INCH)			PASS/ FAIL	DATE TO LAB PKG. SLIP NO.	LAB PASS/ FAIL	COMMENTS

CERTIFICATE OF COMPLETION

TYPE: PARTIAL ____ SUBSTANTIAL ____ FINAL____

PROJECT NAME: ______________________________

SITE NAME: ______________________________

DATE: ______________________________

DESCRIPTION OF WORK CERTIFIED:

____

____

I HEREBY CERTIFY THAT THE ABOVE IDENTIFIED WORK HAS BEEN INSPECTED AND THAT IT HAS BEEN PROPERLY INSTALLED. I FURTHER CERTIFY THAT ALL REQUIRED TESTING HAS BEEN COMPLETED AND THE RESULTS HAVE BEEN DEEMED ACCEPTABLE BY THE GEOSYNTHETIC QAE. THE WORK IS SUITABLE FOR ITS INTENDED USE.

GEOSYNTHETIC QAE

SIGNATURE: ______________________________ DATE: ________

NAME (PRINT): ______________________________

TITLE: ______________________________

REPRESENTING: ______________________________

INSTALLER'S REPRESENTATIVE

SIGNATURE: ______________________________ DATE: ________

NAME (PRINT): ______________________________

TITLE: ______________________________

REPRESENTING: ______________________________

SOLUTIA REPRESENTATIVE

SIGNATURE: ______________________________ DATE: ________

NAME (PRINT): ______________________________

TITLE: ______________________________

REPRESENTING: ______________________________

CERTIFICATE OF COMPLETION

OF SOIL SUBGRADE SURFACE

DATE: ________

PROJECT NAME: ____

SITE NAME: ____

LOCATION OF SUBGRADE SURFACE TO BE LINED: ____________________

____

____

I HEREBY CERTIFY THAT THE ABOVE AREA IS SUITABLE FOR THE INSTALLATION OF GEOSYNTHETICS, AND THAT I SHALL BE RESPONSIBLE FOR ITS INTEGRITY AND SUITABILITY IN ACCORDANCE WITH THE SPECIFICATIONS FROM THIS DATE TO COMPLETION OF THE INSTALLATION.

INSTALLER'S REPRESENTATIVE

NAME (PRINT): ____________________________ DATE: __________

TITLE: ____

REPRESENTING: ____

SIGNATURE: ____

ACKNOWLEDGED BY:

GEOSYNTHETIC QUALITY ASSURANCE CONSULTANT

NAME (PRINT): ____________________________ DATE: __________

TITLE: ____

REPRESENTING: ____

SIGNATURE: ____

APPENDIX G

CONSTRUCTION QUALITY ASSURANCE MANUAL FOR INSTALLATION OF SOIL COMPONENTS OF THE LINING AND FINAL COVER SYSTEMS FOR THE SAUGET AREA 1 TSCA LANDFILL

CONSTRUCTION QUALITY ASSURANCE MANUAL FOR INSTALLATION OF SOIL COMPONENTS OF THE LINING AND FINAL COVER SYSTEMS FOR THE SAUGET AREA 1 LANDFILL CAHOKIA, ILLINOIS

Prepared for:

Solutia Inc.
575 Maryville Centre Drive
St. Louis, MO 63141

Prepared by:

URS
7650 West Courtney Campbell Causeway
Tampa, Florida 33607-1462
C100004051.00

April 2, 2001 Revision 1

TABLES OF CONTENTS

List of Tables, Figures and Appendices

Tables

Figures

Appendices

This manual describes Construction Quality Assurance (CQA) procedures for the installation of the soil components of lining and final cover systems during construction of the Sauget Area 1 TSCA Landfill located in Cahokia, Illinois. This manual addresses only the soil components of the liner and cover systems. CQA guidelines for geosynthetic materials are covered in Solutia's Construction Quality Assurance Manual for Installation of Geosynthetic Components.

All parties listed in Section 2.1, as they become involved in this project, will be issued a copy of this Construction Quality Assurance Manual (CQA Manual) from the Owner or Construction Manager. They will also be given other quality assurance documents specifically prepared for the project, as appropriate.

This manual is to be the basis of the overall CQA program for soil components of lining and final cover systems. Site-specific addenda will be prepared as appropriate by the Construction Manager or his designee.

The overall goals of this CQA program are to ensure that proper construction techniques and procedures are used and to verify that the materials and installation techniques used meet project specifications. The main emphasis of the CQA Manual is careful documentation during the entire quality assurance process, from the selection of materials through the installation of final cover. In addition, the program will 1) identify and define problems that may occur during construction, and 2) ensure that these problems are corrected before the construction is complete. At completion of the work, the program will culminate in a certification report which documents that the earthwork has been constructed in accordance with the project plans and specifications. This certification is the responsibility of the Construction Quality Assurance Consultant (CQA Consultant).

2.1 DEFINITIONS

This manual has been developed for the application of construction quality assurance and quality control procedures to the soil components of liner and final cover systems. CQA and quality control are defined as follows:

> Construction Quality Assurance (CQA) - a planned and systematic application of all means and actions designed to provide adequate confidence that items or services meet design and specifications requirements and will perform satisfactorily in service. In the context of this project. CQA refers to means and actions employed by the Construction Manager and the CQA Consultant to ensure conformity of the soil components of the lining and final cover systems in accordance with the requirements of the Plans, Specifications and the guidelines set forth in this CQA Manual.
>
> Quality Control - those actions which provide a means to measure and regulate the characteristics of an item or service to design and specifications requirements. In the context of this project, quality control refers to those actions taken by the Earthwork Contractor to ensure that the product and the workmanship meet the requirements of the Plans and Specifications.
>
> Project Plans and Specifications - includes all Specifications and engineering drawings developed for this project and any modifications thereto.
>
> Site Specific Addenda - those documents and/or modifications to the CQA manual(s) that are developed to address specific design requirements for a given project.

2.2 PROJECT ORGANIZATION

Solutia has the overall responsibility for ensuring that all construction activities fulfill the objectives of the project. Solutia will retain an independent construction manager to coordinate all activities for construction of the TSCA Landfill. Solutia will also retain an independent firm to provide CQA services for this project. Figure 1-1 presents an organization chart for the project.

Key personnel and their authority and responsibilities with respect to the quality assurance functions for this project are as follows:

2.2.1 Solutia Leadership Team

The Solutia Leadership Team will represent Solutia (the Owner) and has overall responsibility for the conduct of project activities. The team will ensure that corporate standards are applied during the project and will have the overall responsibility to ensure the project meets all established QA/QC goals. The Leadership Team will provide the lead for contact with all regulatory agencies. They are also the primary point of contact between Solutia and all supporting team members. The team is responsible for coordination of project activities between the Designer and the Construction Manager. The Solutia Leadership Team will perform its duties under the direction of Bruce Yare and Mike Light.

2.2.2 Construction Manager

Acting under the authority delegated to him by Solutia, the Construction Manager is the on-site representative and will implement the overall project plans through day-to-day direction of field activities. A construction management firm will be selected to perform these services.

2.2.3 Designer

The Designer is the individual and/or firm responsible for the preparation of the design, including Plans and project-specific Specifications for the soil components of the lining and final cover systems. The Designer for the TSCA Landfill is URS Corporation Southern (URS).

2.2.4 Construction Quality Assurance Consultant

The CQA Consultant is a firm independent from the Construction Manager and Earthwork Contractor that shall be responsible for observing and documenting activities related to the quality assurance of the production and installation of the soil lining components on behalf of Solutia.

2.2.5 Construction Quality Assurance Laboratory

The Construction Quality Assurance Laboratory (CQA Laboratory) is a firm, independent from the Construction Manager and Earthwork Contractor, responsible for conducting tests on samples of soil components taken from the site. A laboratory will be selected to perform geotechnical and soil testing for the project.

2.2.6 Earthwork Contractor(s)

Selected Contractors will be responsible for performing the work outlined in the Construction Plans and Specifications. This work shall include:

- Site mobilization and demobilization
- Site Preparation
- Construction of the soil components of the TSCA Landfill Liner System
- Construction of the soil components of the TSCA Landfill Final Cover System

2.3 PROJECT TEAM RESPONSIBILITIES AND QUALIFICATIONS

The parties discussed in this section are associated with the ownership, design, construction, installation, and quality assurance of the soil components of the lining and final cover systems. The qualifications and responsibilities of these parties are outlined in the following subsections.

2.3.1 Construction Manager

2.3.1.1 Responsibilities

The Construction Manager is responsible for all construction quality. The Construction Manager is responsible for the organization and implementation of the quality assurance activities for the project. The Construction Manager shall serve as communications coordinator for the project, initiating all construction meetings. As communications coordinator, the Construction Manager shall serve as a liaison between all parties involved in the project to insure that communications are maintained.

The principal responsibilities of the Construction Manager are:

- Establish effective communications with the Solutia Leadership Team, Contractor field representatives, and other project team personnel through correspondence, meetings, and discussions, as required, to maintain close working relationships.
- Execute the project work plans and implement procedures through overall planning and day-to-day direction of field activities.
- Ensure that QA/QC procedures are implemented throughout execution of the work.
- Review Contractor progress reports and payments.
- Issue weekly field activity reports.
- Maintain on-site documentation consisting of procedures, rules and regulations, drawings, survey information, correspondence, meetings, etc.
- Manage and assist other field personnel in overseeing Contractors.

The Construction Manger shall also be responsible for proper resolution of all quality assurance issues that arise during construction.

2.3.1.2 Qualifications

The selection of the Construction Manager is the direct responsibility of Solutia. Qualifications for this position include but are not limited to familiarity with the following:

1. Applicable construction methods and procedures.
2. General soil components of the lining and final cover system.
3. All applicable regulatory requirements.
4. Company policies and procedures for project management.
5. Quality assurance requirements.

2.3.2 Designer

2.3.2.1 Responsibilities

The Designer is responsible for performing the engineering design and preparing the associated Plans and Specifications for the soil components of the lining and final cover systems. The Designer is responsible for approving all design and specification changes and making design clarifications necessitated during construction of the soil components of the lining and final cover systems.

2.3.2.2 Qualifications

The Designer shall be a qualified engineer, certified or licensed as required by regulation. The Designer shall be familiar with soil and earth materials, geotechnical design procedures and applicable regulatory requirements.

2.3.2.3 Submittals

The Designer shall submit the project design Plans and Specifications to the Solutia Leadership Team and Construction Manager.

2.3.3 Earthwork Contractor

2.3.3.1 Responsibilities

The Earthwork Contractor is responsible for execution of the requirements of the Plans and Specifications for construction of the lining and final cover systems for the TSCA Landfill.

2.3.3.2 Qualifications

The Earthwork Contractor shall provide the following information to the Construction Manager:

- A demonstration of bonding capability and a list of outstanding contracts.
- A list of comparable projects for which the following information shall be provided for each project:
  - Name of the facility, its location, and date of installation.
  - Name of project manager or contact person for the installation.
  - Description and purpose of installation and definition of contractor's scope of work.
- A list of readily available equipment required to perform the work, at a minimum generally consisting of scrapers, graders, scarifiers, compactors, disking equipment, water trucks, and admixing equipment as appropriate.

2.3.4 Construction Quality Assurance Consultant

2.3.4.1 Responsibilities

The CQA Consultant is responsible for observing and documenting activities related to the quality assurance of the production and installation of the soil components of the lining system. The CQA Consultant is responsible for implementation of the project Quality Assurance Manual and management of the CQA Laboratory. The CQA Consultant is also responsible for issuing a final certification report sealed by a registered professional engineer.

The specific duties of the CQA Consultant are as follows:

a. Review all design drawings and specifications.
b. Review other site-specific documentation, including proposed layouts, and manufacturer's and installer's literature.
c. Review all changes to design drawings and specifications as issued by the Designer.
d. Attends all quality assurance related meetings, e.g., pre-construction, daily, weekly.
e. Manages the preparation of the as-built drawing(s).
f. Reports to the Construction Manager, and logs in the daily report, any relevant observations.
g. Prepares the weekly summary of soil quality assurance activities.
h. Oversees the marking, packaging and shipping of all laboratory test samples.
i. Reviews the results of laboratory testing and makes appropriate recommendations.
j. Reports any unapproved deviations from the Plans and Specifications to the Construction Manager.
k. Prepares the final certification report.

2.3.4.2 Qualifications

The CQA Consultant shall be experienced in quality assurance of soil components of the lining and final cover system. The CQA Consultant shall be experienced in the preparation of quality assurance documentation including: quality assurance forms, reports, certifications, and manuals.

2.3.5 Construction Quality Assurance Laboratory

2.3.5.1 Responsibilities

The CQA Laboratory shall be responsible for conducting the appropriate laboratory tests as directed by the Construction Manager or his designee. The test procedures shall be done in accordance with the test methods outlined in this CQA Manual and/or the project specifications. The CQA Laboratory shall be responsible for providing test results. The selected laboratory will also have responsibility for all bench level QA/QC, data reduction, reporting, and performance monitoring.

2.3.5.2 Qualifications

The CQA Laboratory shall have experience in testing soils in accordance with American Society for Testing and Materials (ASTM) or other applicable test standards.

3.1 PRE-CONSTRUCTION MEETING

A pre-construction meeting shall be held at the site. At a minimum, the meeting shall be attended by the Earthwork Contractor, the Designer, the CQA Consultant, the Solutia Leadership Team and the Construction Manager. The purpose of the pre-construction meeting is to:

- Provide all parties with any relevant documents.
- Review the Plans and Specifications provided by the Designer.
- Review the responsibilities of each party.
- Review lines of authority and communication.
- Review procedures for documentation and reporting of information.
- Discuss any appropriate modification of the CQA Plan (i.e., ensure that site-specific considerations are added, and review any special permit conditions or state/federal requirements that may need to be included).
- Review distribution and storage of documents and reports.
- Review of the Earthwork Contractor's quality control procedures.
- Establish protocol for testing.
- Establish protocol for handling construction deficiencies, and repairs and retesting.
- Conduct a site walk-around to discuss work plans and inspect material handling, borrow, and stockpiling locations, as well as areas that may be required for temporary storage or use.
- Review a time schedule for all operations.
- Review work area security and safety protocol.
- Discuss and establish procedures for material processing (moisture condition, soil blending, etc.).
- Discuss and establish procedures for care and control of water, protection from wind, drying, dust control, and general liner protection and housekeeping.
- Review health and safety requirements applicable to all parties.
- Develop site-specific addenda to the CQA Manual for the proposed project.

The meeting shall be documented by the Construction Manager or a person designated at the beginning of the meeting, and minutes shall be transmitted to all parties prior to the start of construction.

3.2 PROGRESS MEETINGS

A progress meeting shall be held at least weekly at the work area. Progress meetings shall be conducted at other times during the project as appropriate or necessary as determined by the

Construction Manager. At a minimum, the meeting shall be attended by the Earthwork Contractor, the CQA Consultant and the Construction Manager. The purpose of the meeting is to:

- Review the previous week's activities and accomplishments.
- Review the work activity and location for the week.
- Discuss the earthwork contractor's personnel and equipment assignments.
- Review the work schedule.
- Discuss possible problems.
- Review any new test data.

The meeting shall be documented by the Construction Manager.

3.3 PROBLEM OR WORK DEFICIENCY MEETING

A special meeting shall be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting shall be attended by the Earthwork Contractor, the Construction Manager, and the CQA Consultant. If the problem requires a design modification, the Designer should also be present. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency.
- Review alternative solutions.
- Implement an action plan to resolve the problem or deficiency.

The meeting shall be documented by the Construction Manager.

4.1 GENERAL

Construction of the soil components for the lining and final cover system as well as other specified earthwork must be in strict accordance with the project Plans and Specifications. Compliance is confirmed by checking that: 1) the earthen backfill materials will exhibit the required characteristics, and 2) the placement techniques used by the Earthwork Contractor will be adequate.

CQA related activities for construction of the soil components of the lining and final cover system will include observation, independent testing and documentation of the following:

- Pre-construction Testing for Material Evaluation
- Construction Testing
- Post-construction Testing

4.2 MATERIAL EVALUATION

4.2.1 General

The types of soils used in lining systems include compacted fill, tracked-in-place fill, drainage material, protective fill and vegetative cover soil. Prior to construction, sources for each of these materials shall be identified, and samples of each material from each source shall be tested to determine whether they meet project specifications.

This manual focuses on material tests conducted during the construction phase. These tests must be performed to confirm that the procured material meets project specifications before it is accepted for construction. Further material testing is necessary if alternative borrow material is required during construction or if soils are processed on site (i.e., when drainage materials are washed to increase their permeability). All material evaluation tests are to be performed by the CQA Laboratory or in a geotechnical laboratory approved for use by the Construction Manager.

4.2.2 Laboratory Soils Tests

Tests to confirm the adequacy of procured materials shall be performed as part of the Earthwork Contractors QC activities on each material from each source area. All tests shall be documented, and the material shall be accepted or rejected according to the results of these tests. Testing of samples shall be performed in accordance with the requirements of the Plans and Specifications. The CQA Consultant shall confirm the minimum number if required tests were performed and that the test results appear valid. If the results appear questionable he shall direct the Earthwork Contractor to perform additional testing. Independent testing will be performed as deemed appropriate by the CQA Consultant or as otherwise directed by the Construction Manager.

4.2.3 Soils Selection Criteria

All soil material used during construction shall meet the minimum criteria in the project specifications, unless otherwise directed by the Construction Manager. Table 1 includes the testing frequencies required by the Specifications.

4.2.3.1 Compacted Fill

Compacted Fill shall consist of random granular or cohesive material obtained from approved borrow areas. Compacted Fill may be used for construction of the following soil components:

- Subgrade
- Perimeter Berms

Compacted Fill may also be used to adjust or modify the slope of subgrade soils. Compacted Fill shall meet the minimum requirements given in the Plans and Specifications. Compacted Fill shall consist of the following soil types:

- Silty to Clayey Sands
- Silty Sands
- Clayey Silts to Silty Clays
- Silty Sandy Clays
- Combinations of the above

The Earthwork Contractor shall furnish representative samples of the Compacted Fill to the CQA Consultant and Construction Manager for each material source he may use. In addition the results of the following tests shall be provided to the CQA Consultant and Construction Manager for approval prior to procurement, importing or stockpiling the materials:

• Moisture Content	ASTM D 2216
• Atterburg Limits	ASTM D 4318
• Particle Size	ASTM D 1140
• Moisture Density Relationship	ASTM D 698

4.2.3.2 Tracked-in Place Fill

Tracked-in Place Fill shall consist of poorly graded granular or cohesive fill obtained from approved borrow areas. Tracked-in Place Fill will be used in conjunction with construction of the liner and cover systems. Tracked-in Place Fill shall meet the minimum requirements of the Plans and Specifications. Tracked-in Fill shall consist of the following soil types:

- Silty to Clayey Sands
- Clayey Silts or Silty Clays
- Sandy Clays
- Combinations of the above

The Earthwork Contractor shall furnish representative samples of the Tracked-in Fill to the CQA Consultant and Construction Manager for each material source he may use. In addition the results of the following tests shall be provided to the CQA Consultant and Construction Manager for approval prior to procurement, importing or stockpiling the materials:

• Moisture Content	ASTM D 2216
• Atterburg Limits	ASTM D 4318
• Particle Size	ASTM D 1140
• Moisture Density Relationship	ASTM D 698

4.2.3.3 Drainage Material

Drainage Material shall consist of granular soils obtained from approved on-site or off-site borrow areas. Drainage Material will be used for construction of the following soil components:

- Primary and Secondary Collection System Layer
- Primary and Secondary Collection Sump Gravel
- Gravel Drains for Primary Collection Layer
- Capillary Break Layer

Drainage Material shall meet the minimum requirements given in the Plans and Specifications. Drainage Material shall consist of the following soil types:

- Sandy Gravel to Sandy Silty Gravel
- Well Graded to Poorly Graded Gravels
- Silty Sands
- Well Graded to Poorly Graded Sands

The Earthwork Contractor shall furnish representative samples of the Drainage Material to the CQA Consultant and Construction Manager for each material source he may use. In addition the results of the following tests shall be provided to the CQA Consultant and Construction Manager for approval prior to procurement, importing or stockpiling the materials:

- Moisture Content ASTM D 2216
- Particle Size ASTM D 422
- Permeability ASTM D 2434

4.2.3.4 Protective Fill

Protective Fill shall consist of granular or fine-grained cohesive material obtained from approved borrow areas, or other sources as approved by the Construction Manager. Protective Fill will be used to construct the protective soil layer placed directly on the Primary Collection System. Protective Fill shall meet the minimum requirements of the Plans and Specifications. Protective Fill shall consist of the following soil types:

- Silty to Clayey Sands
- Poor to Well Graded Sands
- Sandy to Silty Clays
- Sediments
- Combinations of the above

If the Protective Fill consists of unaffected soils, the Earthwork Contractor shall furnish representative samples of the Protective Fill to the CQA Consultant and Construction Manager for each material source proposed. In addition, the results of the following tests shall be provided by the Earthwork Contractor to the CQA Consultant and Construction Manager for approval prior to procurement importing or stockpiling the materials:

- Moisture Content ASTM D 2216
- Particle Size ASTM D 422 or D 1140
- Moisture Density ASTM D 698

Protective Fill shall be free of rocks, gravel, sticks, roots or unsuitable materials.

4.2.3.5 Vegetated Cover Fill

Vegetated Cover Fill shall consist of granular material obtained from approved on-site or off-site borrow areas. Vegetated Cover Fill will be used for construction of the final cover layer (i.e. Vegetated Cover and Drainage Layer). Vegetated Cover Fill shall meet the minimum requirements given in the Plans and Specifications. Vegetated Cover Fill shall consist of the following soil types:

- Silty Sands
- Clayey Sands
- Silty to Clayey Sands

- Topsoil
- Combinations of the above

The Earthwork Contractor shall provide the CQA Consultant and Construction Manager with representative samples of Vegetated Cover Fill for each material source he may use. In addition the results of the following tests shall be provided to the CQA Consultant and Construction Manager for approval prior to procurement, importing or stockpiling the materials:

• Moisture Content	ASTM D 2216
• Atterberg Limits	ASTM D 4318
• Particle Size	ASTM D 422 (for granular soils)
• Particle Size	ASTM D 1140 (for granular soils)
• Moisture Density	ASTM D 698
• Permeability	ASTM D 2434 or ASTM D 5084

4.2.4 Earth Fill Material Management

As the material is excavated from an approved borrow facility, the CQA Consultant shall confirm that the soils meet the requirements of the Specifications. The CQA Consultant will use his/her experience with visual/manual soil classification techniques to assess the segregation of soils. The CQA Consultant will note in his/her field records changes in odor, texture, apparent moisture, and the depths of which they occur. The CQA Consultant shall confirm that adequate processing, as described in the Specifications, is performed for removal of roots, rocks, rubbish or unsuitable materials, and achieve the specified soil clod size. Off-site borrow will be sampled and analyzed for TCL/TAL constituents at a rate of one sample every 5,000 cubic yards. Results will be compared to TACO Tier I criteria for commercial/industrial area soils. Soil with concentrations higher than these levels will not be accepted for use in containment cell construction.

Materials from the excavation will be stockpiled in areas approved by the Construction Manager and protected. If excavated soils exhibit distinct characteristic changes with depth, the CQA Consultant should verify that stockpiles be segregated by depth, and the depth range of the stockpiles be recorded and posted. Each stockpile shall be identified, and the CQA Consultant should prepare a field drawing of stockpile locations.

4.3 CONSTRUCTION QUALITY EVALUATION

Construction quality evaluation shall be performed on all components of the construction. Criteria to be used for determination of acceptability of the construction work shall be as identified in the Specifications. Tables 2 and 3 present the testing frequencies required in the Specifications.

4.3.1 Subgrade Evaluation

During construction, the subgrade soil shall be evaluated in accordance with the Specifications to confirm that its characteristics are equivalent to those utilized in the design of the lining systems. Subgrade damage due to excess moisture (causing softening) or insufficient moisture (causing desiccation and shrinkage), shall be identified and repaired.

At a minimum, the CQA Consultant shall determine the suitability of the subgrade for placement of the Remolded and Compacted Soils by continuous visual inspection during proof rolling.

Final subgrade elevations shall be measured and recorded by the Earthwork Contractor. The CQA Consultant shall confirm that all subgrade elevations are in accordance with the Plans and Specifications. The CQA Consultant shall notify the Construction Manager and Earthwork Contractor of deficiencies in subgrade elevation or characteristics.

4.3.2 Fill Placement

The Earthwork Contractor will be responsible for implementing a Construction Quality Control program (CQC) to ensure that all earthwork is performed in accordance with the Plans and Specifications. The CQA Consultant will oversee the Earthwork Contractor's CQC plan and will document and observe the construction activity. The responsibilities of the CQA Consultant include the following:

- Document that roots, rocks, rubbish or off-spec materials;
- Evaluation of soil materials to be used for clay liner and cover, sand and gravel drainage layers, and general fill;
- Observation of compaction performance of Earthwork Contractor's equipment and techniques;
- Documentation of excavation and segregation of soils suitable for use;
- Evaluation of stockpiling activities and stockpile fill suitable for use;
- Evaluation of subgrade slopes and bottom for proper grade and soil condition;
- Observation Inspection of drainage layer installation; and
- Evaluation of lift thickness and compaction.

4.3.3 Evaluation of Layer Bonding

Evaluation of layer bonding will be determined by collecting one Shelby tube sample for every 10,000 square feet of compacted bottom soil. Shelby tubes will only be pushed eight inches in order to protect the underlying liner system. Sample holes will be filled with bentonite.

The CQA Consultant shall confirm that layer bonding between compacted lifts is adequate and that discontinuities do not appear to exist. This will be accomplished by cutting the Shelby tube sample in half longitudinally and visually examining the sample. The CQA Consultant shall notify the Construction Manager of any layer bonding deemed to be deficient and shall confirm that repairs are performed by the Earthwork Contractor.

4.3.4 Construction Quality Control Testing

Laboratory and field tests shall be performed by the Earthwork Contractor in accordance with the requirement of the Plans and Specifications.

The CQA Consultant shall observe the CQC testing and review all test results from both laboratory and field-testing. He shall confirm that the minimum testing is performed in accordance with the Specifications. He shall confirm that the CQC testing results adequately indicates that earthwork construction meets or exceeds design requirements in accordance with the Plans and Specifications.

Questions concerning the accuracy of any single test shall be addressed by retesting in the same or adjoining locations. Periodic checks using the drive cylinder method shall be performed in accordance with the Specifications to confirm the nuclear density results.
Additional testing shall be used at the discretion of CQA Consultant and/or the Construction Manager when visual observations indicate a potential problem. Additional testing for suspect areas shall be considered when:

- Compactor slippage during rolling operation;
- Lift thickness is greater than specified;
- Earthfill is at improper and/or variable moisture content;
- Less than specified number of compactor (roller) coverages are made;
- Dirt-clogged rollers are used to compact the material;
- Rollers may not have used optimum ballast;
- Fill materials differ substantially from those specified; and
- The degree of compaction is doubtful.

During construction, the frequency of testing may also be increased in the following situations:

- Adverse weather conditions;
- Breakdown of equipment;
- At the start and finish of grading;
- Materials fail to meet specifications; and
- The work area is reduced.

4.3.5 Perforations

All perforations must be backfilled. These shall include, but not be limited to, the following:

- Density test locations
- Permeability sampling locations
- Shelby tube locations

Unless otherwise noted in the Specifications, or as directed by the Construction Manager, all perforations shall be backfilled with bentonite powder or soil equivalent to the soil used for construction of the layer. The soil shall be broken into clod sizes smaller than the perforation diameter and compacted in-place with a tamping rod, Modified or Standard Proctor hammer, or hand tamper depending on the size of the perforation. The CQA Consultant shall confirm that all perforations are properly repaired.

4.4 DEFICIENCIES

4.4.1 Examination of the Deficiency

If a deficiency is discovered in the work, the CQA Consultant shall immediately determine the extent and nature of the deficiency. If the deficiency is indicated by an unsatisfactory test result, the CQA Consultant shall determine the extent of the deficient area by directing the Earthwork Contractor to perform additional tests, observations, a review of records, or other appropriate methods. If the deficiency is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Consultant shall define the limits and nature of the deficiency.

4.4.2 Notification

After determining the extent and nature of a deficiency, the CQA Consultant shall notify the Construction Manager and Earthwork Contractor.

4.4.3 Repairs and Retesting

The Earthwork Contractor shall correct the deficiency to the satisfaction of the Construction Manager. If a requirement cannot be met, or unusual weather conditions hinder work, then the CQA Consultant, Construction Manager and Earthwork Contractor shall discuss alternate solutions and a schedule for correction of the deficiency.

All retests performed by the Earthwork Contractor, as directed by the CQA Consultant, must confirm that the deficiency has been corrected before any additional work is performed in the area of the deficiency. The CQA Consultant shall also confirm that all installation requirements are met and that all CQC submittals are provided.

4.5 ACCEPTANCE

The CQA Consultant shall recommend to the Construction Manager acceptance of the work performed by the Earthwork Contractor. Acceptance of the completed work shall be in accordance with the requirements of the Plans and Specifications. Acceptance of the soil components of the lining and final cover systems will be based on observation, measurements and laboratory test results.

The following methods shall be used by the CQA Consultant as the basis to judge the acceptability of the construction of the soil components of the lining and final cover systems.

1. Evaluate the following for a given lift or section:
   - Dry density;
   - Moisture content;
   - Lift thickness; and
   - Clod size.
2. Compare measured results to Specification requirements and determine the variation.
3. If dry density is too low, adjust moisture content as necessary and recompact lift.
4. If moisture content is too dry:
   - Adjust moisture content upward and recompact, or
   - Run laboratory permeability on field-compacted sample.
5. If lift is too thick:
   - Decrease thickness,
   - Check dry density and moisture at bottom of lift, or
   - Run laboratory permeability on field compacted sample.
6. If clod size is too large: inspect test pit(s) to determine integrity of lift and layer bonding.

If two or more items fail to comply, then the lift or section being assessed shall be deemed unacceptable and shall be suitably broken up, moisture content adjusted, recompacted and retested.

An effective CQA Plan depends largely on recognition of all construction activities that should be monitored, and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Consultant shall document that all quality assurance requirements have been addressed and satisfied.

The CQA Consultant shall provide the Construction Manager with signed descriptive remarks, data sheets, and checklists to verify that all monitoring activities have been carried out. The Construction Manager shall also maintain at the job site a complete file of plans and specifications, a CQA manual, checklists, test procedures, daily logs, and other pertinent documents.

5.1 DAILY RECORDKEEPING

Standard reporting procedures will include preparation of a daily log which, at a minimum, shall consist of: a) field notes: including memorandum of meetings and/or discussions with the earthwork contractor, b) observation and testing data sheets, and c) construction problem and solution data sheets. This information will be regularly submitted to and reviewed by the Construction Manager.

5.1.1 Memorandum of Discussion With Earthwork Contractor or Subcontractors

A memorandum will be prepared each day as necessary, summarizing discussions between the CQA Consultant and Earthwork Contractor. At a minimum, the memorandum will include the following information:

- Date, project name, location, and other identification
- Names of parties to discussion
- Relevant subject matter or issues
- Activities planned
- Constraints or suggestions
- Schedule
- Signature of the CQA Consultant

5.1.2 Observation and Testing Data Sheets

Observation and testing data sheets will be prepared daily. At a minimum, these data sheets will include the following information:

- An identifying sheet number for cross referencing and document control
- Date, project name, location, and other identification
- Data on weather conditions

- A reduced-scale site plan showing all proposed work areas and test locations
- Descriptions and locations of ongoing construction
- Equipment and personnel in each work area, including subcontractors
- Descriptions and specific locations of areas, or units, of work being tested and/or observed and documented (identified by lift and location)
- Locations where tests and samples were taken
- A summary of test results
- Calibrations or recalibrations of test equipment, and actions taken as result of recalibration
- Off-site materials received, including quality verification documentation
- Decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality
- The CQA Consultant signature

5.2 CONSTRUCTION PROBLEM AND RESOLUTION DATA SHEETS

Sheets describing special construction situations shall be cross-referenced with specific observation and testing data sheets, and must include the following information, where available:

- An identifying sheet number for cross-referencing and document control
- A detailed description of the situation or deficiency
- The location and probable cause of the situation or deficiency
- How and when the situation or deficiency was found or located
- Documentation of the response to the situation or deficiency
- Final results of any responses
- Any measures taken to prevent a similar situation from occurring in the future
- The signature of the CQA Consultant and signature indicating concurrence by the Construction Manager

The Construction Manager shall be made aware of any significant recurring non-conformance with the Specifications. The Construction Manager shall then determine their cause and recommend appropriate changes in procedures or Specifications. When this type of evaluation is made, the results must be documented, and any revision to procedures or Specifications shall be approved by the Designer.

A summary of all supporting data sheets, along with final testing results and the CQA Consultant's concurrence that the work is completed in accordance with the requirements of the

Plans and Specifications, shall be required upon completion of the repair, replacement or resolution of the issue.

5.3 PHOTOGRAPHIC REPORTING DATA SHEETS

Photographic reporting data sheets, where used, shall be cross-referenced with observation and testing data sheet(s) and/or construction problem and solution data sheet(s).

These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints; negatives will also be stored in a separate file in chronological order. These records shall be presented to the Construction Manager upon completion of the project.

5.4 DESIGN AND/OR SPECIFICATIONS CHANGES

Design and/or specifications changes may be required during construction. In such cases, the CQA Consultant shall notify the Construction Manager and Designer.

Design and/or specifications changes shall be made only with written agreement of the Construction Manager and the Designer, and shall take the form of an addendum to the Specifications.

5.5 PROGRESS REPORTS

The Construction Manager shall prepare a summary progress report each week, or at time intervals established at the pre-construction meeting. As a minimum, this report shall include the following information:

- A unique identifying sheet number for cross-referencing and document control
- The date, project name, location, and other information
- A summary of work activities during progress reporting period
- A summary of construction situations, deficiencies, and/or defects occurring during progress reporting period
- A summary of test results, failures and retests
- The signature of the Construction Manager

5.6 CERTIFICATION AND SUMMARY REPORT

At the completion of the work, the CQA Consultant shall submit to the Construction Manager a final certification and summary report. This report shall certify that the work has been performed in compliance with the Plans and Specifications.

At a minimum, this report shall include: a) summaries of all construction activities, b) observation and testing data sheets including sample location plans, c) construction problems and resolutions data sheets, d) changes in design and material specifications, e) as-built drawings, and f) certification statement sealed and signed by a registered Professional Engineer. The as-built drawings shall include scale drawings depicting the location of the construction and details pertaining to the extent of construction (depths, plan dimensions, elevations, soil component thicknesses, etc.). All surveying and base maps required for development of the as-built drawings shall be done by a qualified land surveyor.

5.7 STORAGE OF RECORDS

All handwritten data sheet originals, especially those containing signatures, should be stored by the Construction Manager in a safe repository on site. Other reports may be stored by any standard method which will allow for easy access.

TABLES

TABLE 1

PRE-CONSTRUCTION TESTING FREQUENCY FOR MATERIALS EVALUATION OF SOIL COMPONENTS OF LINING AND FINAL COVER SYSTEMS

SAUGET AREA 1 TSCA LANDFILL
SOLUTIA INC.
CAHOKIA, ILLINOIS

Test Type and ASTM Description	Compacted Fill (cu yd)	Tracked-in Place Fill (cu yd)	Drainage Material Sand (cu yd)	Drainage Material Gravel (cu yd)	Protective Fill (cu yd)	Vegetative Cover (cu yd)
Moisture Content (D2216)	2 per source *	1 per source *	1 per source *	1 per source *	1 per source *	2 per source *
Atterberg Limits (D4318)	2 per source *	1 per source *	----------	----------	1 per source *	2 per source *
Particle Size (Clays – D1140) (Sands, Gravel – D422)	2 per source *	1 per source *	1 per source *	1 per source *	1 per source *	2 per source *
Moisture Density (D698)	2 per source *	1 per source *	----------	----------	1 per source *	2 per source *
Permeability (Clays – D5084) (Sands, Gravel – D2434)	--------	---------	1 per source *	1 per source *	---------	2 per source *

* = And for each change in material

TABLE 2

CONSTRUCTION TESTING FREQUENCY
OF SOIL COMPONENTS OF LINING AND FINAL COVER SYSTEMS

SAUGET AREA 1 TSCA LANDFILL
SOLUTIA INC.
CAHOKIA, ILLINOIS

Test Type and ASTM Description	Compacted Fill (cu yd)	Tracked-in Place Fill (cu yd)	Drainage Material Sand (cu yd)	Drainage Material Gravel (cu yd)	Protective Fill (cu yd)	Vegetative Cover (cu yd)
Moisture Content (D 2216)	1 per 15,000 *	1 per 5,000 *	1 per 5,000 *	1 per 5,000 *	1 per 5,000 *	1 per 10,000 *
Atterberg Limits (D 4318)	1 per 15,000 *	1 per 5,000 *	----------	----------	----------	1 per 10,000 *
Particle Size (Clays – D 1140) (Sands, Gravel – D 422)	1 per 15,000 *	1 per 5,000 *	1 per 5,000 *	1 per 5,000 *	1 per 5,000 *	1 per 10,000 *
Moisture Density (D 698)	1 per 15,000 *	1 per 10,000 *	----------	----------	1 per 5,000 *	1 per 10,000 *
Permeability (Clays - D 5084) (Sands, Gravel - D 2434)	-------	---------	1 per 5,000 *	1 per 5,000 *	----------	1 per 10,000 *

* = For each material type placed

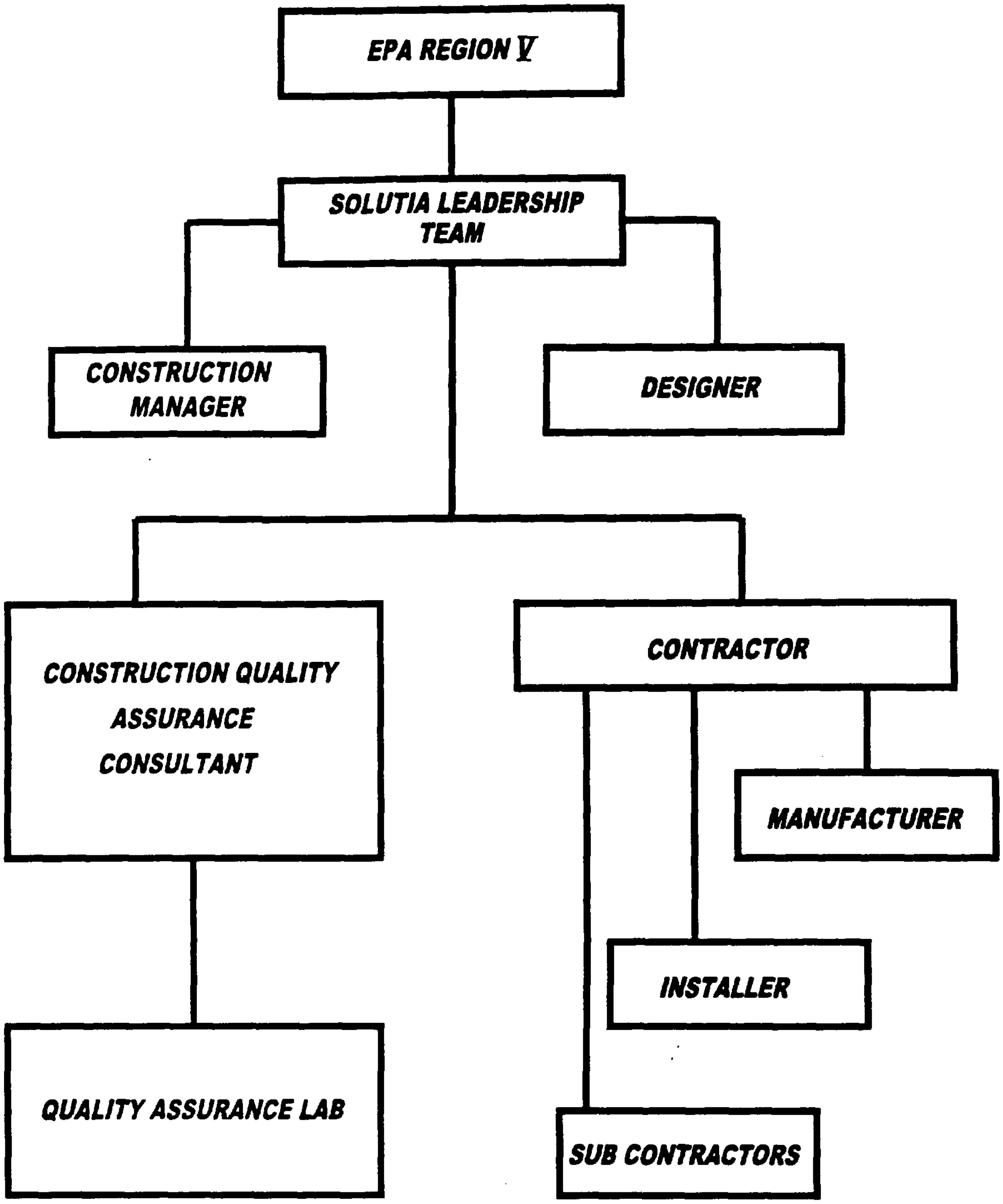
TABLE 3

POST CONSTRUCTION TESTING FREQUENCY OF SOIL COMPONENTS OF LINING AND FINAL COVER SYSTEMS

SAUGET AREA 1 TSCA LANDFILL
SOLUTIA INC.
CAHOKIA, ILLINOIS

Test Type and ASTM Description	Compacted Fill	Tracked-in Place Fill	Drainage Material Sand	Drainage Material Gravel	Protective Fill	Vegetative Cover
Field Placed Moisture and Density (D 2922/D 3017)	1 per 2,000 yd^3	1 per 10,000 ft^2 or 6 per lift (minimum)	----------	----------	----------	1 per 2,000 yd^3
Field Placed Density/Moisture Verification (D 2937/D 2216)	1 per 15,000 yd^3	1 per 2,000 yd^3 or 1 per lift (minimum)	----------	----------	----------	----------
Layer Bonding	----------	1 per layer	----------	----------	----------	----------
Survey of As Built Configuration	• Base of fill • Completed section • As directed	All appurtenant components 50 feet center to center or minimum 6 points per grade at least the following locations: • Base of excavation • Top of first clay lift for each layer • Top of all collection systems • Base and top of all sumps and drains • As directed by the owner or his representative				
Inplace Permeability	----------	----------	----------	----------	----------	----------

FIGURES



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PREPARED FOR: SOLUTIA	Drawn:	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE 1-1
URSGWC JOB NUMBER: C100003899.00	Design:		
URS Greiner Woodward Clyde A Division of URS Corporation 7650 W. Courtney Campbell Causeway Tampa, Florida 33607-1462 Tel: 813.286.1711 Fax: 813.287.8591	Checked: G. WANTLAND	DRAWING TITLE CONSTRUCTION QUALITY ASSURANCE PROTECT ORGANIZATION CHART	
	Date: OCT. 30, 2000		

APPENDIX A

CONSTRUCTION QUALITY ASSURANCE CHECKLIST

I. SUBMITTAL OF QUALIFICATIONS

A. Earthwork Contractor (2.3.1)

1. Demonstration of bonding capability and list of outstanding contracts. ________
2. A list of five comparable projects. ________
   a. Name of facility, location, and date of installation. ________
   b. Name of project manager or contact person for installation. ________
   c. Description and purpose of installation and definition of contractor's scope. ________
3. A list of readily available equipment. ________

B. CQA Consultant (2.3.2)

1. Corporate Information
   a. Corporate history ________
   b. Proof of insurance ________
      1) professional liability ________
      2) "umbrella" coverage ________
      3) other coverages required by state and local Statutes or proposed contractual agreements. ________
2. Inspection Capabilities
   a. Summary of firm's experience with observation and testing, especially soil components for waste facilities. ________
   b. Summary of firms experience in CQA/QC (emphasis on soil components). ________
3. Personnel
   a. Resumes of personnel to be involved in the project. ________
   b. Supervising engineer must have proof of engineering degree and/or professional engineering registration in project state. ________
   c. Specific experience with soil components of inspecting personnel. ________

II. MEETINGS

A. Resolution Meeting (with Design Engineer, Owner, Project Manager, and CQA Monitor Present) (3.1)

1. Provide all parties with relevant documents. ________

2. Review plans and specifications. ______
3. Make modifications to CQA plan. ______
4. Review of the CQA plan and quality control procedures. ______
5. Review and assign responsibilities to parties. ______
6. Establish procedures for documentation and reporting information. ______
7. Establish methods for distribution and storage of documents and reports. ______
8. Prepare a time schedule for operations. ______
9. Establish work area security and safety protocol. ______
10. Discuss and select earthwork contractors to be asked to bid. ______
11. Review special permit conditions and/or state and federal requirements. ______
12. Select testing equipment as well as protocol for testing and placement of soil materials. ______
13. Meeting documented by CQA monitor or designate and minutes transmitted to all parties . ______

B. Pre-Construction Meeting (with Earthwork Contractor, CQA Monitor, and Project Manager present) (3.2) ______

1. Discuss modifications to CQA plan. ______
2. Review special permits and state and federal requirements. ______
3. Review responsibilities of each party. ______
4. Review lines of authority and communication. ______
5. Review procedures for documentation and reporting information. ______
6. Review distribution and storage of documents and reports. ______
7. Establish protocol for testing. ______
8. Establish protocol for handling construction deficiencies. ______
9. Establish protocol for repairs and retesting. ______
10. Conduct site-walk. ______
    a. Discuss work plans. ______
    b. Inspect material handling, borrow, and stockpile locations. ______
11. Review a time schedule for all operations. ______
12. Review work area security and safety protocol. ______

13. Discuss and establish procedures for material processing. ________
14. Establish procedures for control of water and general materials protection and housekeeping. ________
15. Review health and safety requirements. ________
16. Meeting documented by CQA Monitor or designate and minutes transmitted to all parties prior to start of construction ________

C. Progress Meetings with Earthwork Contractor and CQA Monitor (3-3)

1. Review work activity and location for the day. ________
2. Discuss personnel and equipment for the assignment of the day. ________
3. Review previous day's activities and accomplishments. ________
4. Review work schedule. ________
5. Discuss possible problems. ________
6. Review new test data. ________
7. Meeting documented by CQA Monitor. ________

D. Problem or Work Deficiency Meeting (with Earthwork Contractor, Owner, and CQA Monitor present) (3.4)

1. Define and discuss the problem or deficiency. ________
2. Review alternative solutions. ________
3. Implement action plan. ________
4. Meeting documented by CQA Monitor. ________

III. DOCUMENTATION

A. Daily Recordkeeping (completed by CQA Monitor) (5.1)

1. Daily memorandum of discussion with earthwork contractor (fill in appropriate form) ________
2. Observation and testing data sheets (fill in appropriate form) ________

B. Construction Problem and Resolution Data Sheets (5.2) to Include:

1. A unique identifying sheet number ________
2. A detailed description of the situation or deficiency ________
3. Location and probable cause or situation or deficiency ________
4. How and when situation or deficiency was discovered ________
5. Documentation of the response to the situation or deficiency ________

6. Final result of the response ______
7. Measure undertaken to avoid or prevent similar future occurrences ______
8. Signature of the CQA monitor and project manager ______
9. Summary of all supporting data and test sheets required upon completion of construction ______

C. Photographic Reporting Data Sheet (5.3) ______

D. Design and/or Specification Changes (5.4)

1. CQA monitor shall inform the project manager and Design Engineer of any design and/or specification changes ______
2. Design and/or specification changes shall be made only with written agreement of the project manager and the design engineer. This change shall take the form of an amendment to the specification or Construction Quality Assurance Manual. ______

E. Progress Reports (5.5)

1. The CQA monitor shall prepare a summary progress report weekly, or at a frequency established at the pre-construction meeting ______
2. The progress report will include:
   a. A unique identifying sheet number ______
   b. The date, project name, location, and other information ______
   c. A summary of work activities during progress reporting periods ______
   d. A summary of construction situations, deficiencies and/or defects occurring during progress reporting period ______
   e. A summary of test results, failures, and retests ______
   f. The signature of the CQA monitor ______

F. Certification and Summary Report (5.6)

1. The CQA consultant shall submit to the project manager a final certification and summary report that includes:
   a. Summaries of construction activities ______
   b. Observation and testing data sheets with test location plans ______
   c. Construction problems and solutions data sheets ______
   d. Changes from design and material specifications ______
   e. As-built drawings, including:

1) scale drawings with locations and extent of construction ______

2) surveying and base maps required done by qualified land surveyor ______

3) as-built document prepared by the CQA Engineer and included in the CQA plan documentation ______

APPENDIX H

GEOSYNTHETIC MATERIAL DATA SHEETS

GSE

GSE HD*

HDPE Geomembrane

GSE HD is a high quality, high density polyethylene (HDPE) geomembrane produced from a specially formulated, proprietary virgin polyethylene resin. This polyethylene resin is designed specifically for flexible geomembrane applications. GSE HD contains approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. GSE HD has outstanding chemical resistance, mechanical properties, environmental stress crack resistance, dimensional stability and thermal aging characteristics. GSE HD has excellent resistance to UV radiation and is suitable for exposed conditions.

TESTED PROPERTY	TEST METHOD	MINIMUM VALUES				
Thickness, mils (mm)	ASTM D 751/1593/5199	27 (0.68)	36 (0.90)	54 (1.35)	72 (1.80)	90 (2.25)
Density, g/cm^3	ASTM D 792/1505	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 638, Type IV					
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm	122 (21)	162 (28)	243 (43)	324 (57)	405 (71)
Strength at Yield, lb/in-width (N/mm)		65 (11)	86 (15)	130 (23)	173 (30)	216 (38)
Elongation at Break, %	G.L. 2.5 in (64 mm)	560	560	560	560	560
Elongation at Yield, %	G.L. 1.3 in (33 mm)	13	13	13	13	13
Tear Resistance, lb (N)	ASTM D 1004	22 (98)	30 (133)	45 (200)	60 (267)	75 (334)
Puncture Resistance, lb (N)	FTMS 101, Method 2065	39 (174)	52 (231)	80 (356)	105 (467)	130 (579)
Carbon Black Content, %	ASTM D 1603	2.0	2.0	2.0	2.0	2.0
Environmental Stress Crack Resistance, hr	ASTM D 1693, Cond. B	1500	1500	1500	1500	1500

REFERENCE PROPERTY	TEST METHOD	NOMINAL VALUES				
Thickness, mils (mm)	ASTM D 751/1593/5199	30 (0.75)	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Roll Length** (approximate), ft (m)		952 (290)	650 (198)	420 (128)	320 (98)	250 (76)
Low Temperature Brittleness, °F (°C)	ASTM D 746, Cond. B	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)
Oxidative Induction Time, minutes	ASTM D 3895, 200 °C Pure O_2, 1 atm	100	100	100	100	100
Water Absorption, % wt. change	ASTM D 570	<0.01	<0.01	<0.01	<0.01	<0.01
Moisture Vapor Transmission, g/m^{2}day	ASTM E 96	<0.001	<0.001	<0.001	<0.001	<0.001
Carbon Black Dispersion	ASTM D 3015	A1,A2,B1	A1,A2,B1	A1,A2,B1	A1,A2,B1	A1,A2,B1
Dimensional Stability (each direction), %	ASTM D 1204, 100 °C, 1 hr	±2	±2	±2	±2	±2
Melt Flow Index, g/10 minutes	ASTM D 1238, Cond.190/2.16	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0

GSE HD is available in rolls approximately 22.5 ft (6.9 m) and 34.5 ft (10.5 m) wide and weighing about 2,900 lb (1,315 kg) and 4,400 lb (1,995 kg) respectively. Other material thicknesses are available upon request.

** Roll lengths correspond to the 22.5 ft (6.9 m) wide roll goods.

This information is provided for reference purposes only and is not intended as a warranty or guarantee. GSE assumes no liability in connection with the use of this information. Check with GSE for current, standard minimum quality assurance procedures.

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GSE

GSE HD* Textured

Textured HDPE Geomembrane

GSE HD Textured is the textured version of GSE HD. It is a high quality, high density polyethylene (HDPE) geomembrane with one or two co-extruded, textured surfaces, and consisting of approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. The resin used is a specially formulated, proprietary virgin polyethylene and is designed specifically for flexible geomembrane applications. GSE HD Textured has excellent resistance to UV radiation and is suitable for exposed conditions. This product allows projects with greater slopes to be designed since frictional characteristics are enhanced.

TESTED PROPERTY	TEST METHOD	MINIMUM VALUES				
Thickness, mils (mm)	ASTM D 751/1593/5199	27 (0.68)	36 (0.90)	54 (1.35)	72 (1.80)	90 (2.25)
Density, g/cm^3	ASTM D 792/1505	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)[1]	ASTM D 638, Type IV					
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm	38 (7)	50 (9)	75 (13)	100 (18)	125 (22)
Strength at Yield, lb/in-width (N/mm)		65 (11)	86 (15)	130 (23)	173 (30)	216 (38)
Elongation at Break, %	G.L. = 2.5 in (64 mm)	120	120	120	120	120
Elongation at Yield, %	G.L. = 1.3 in (33 mm)	13	13	13	13	13
Tear Resistance, lb (N)	ASTM D 1004	22 (98)	30 (134)	45 (200)	60 (267)	75 (334)
Puncture Resistance, lb (N)	FTMS 101, Method 2065	38 (169)	52 (231)	80 (356)	105 (467)	130 (579)
Carbon Black Content, %	ASTM D 1603	2.0	2.0	2.0	2.0	2.0
Environmental Stress Crack Resistance[2], hr	ASTM D 1693, Cond. B	1500	1500	1500	1500	1500

REFERENCE PROPERTY	TEST METHOD	NOMINAL VALUES				
Thickness, mils (mm)	ASTM D 751/1593/5199	30 (0.75)	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Roll Length (approximate), ft (m)		825 (251)	730 (223)	520 (158)	400 (122)	325 (99)
Low Temperature Brittleness, °F (°C)	ASTM D 746, Cond. B	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)
Oxidative Induction Time, minutes	ASTM D 3895, 200 °C Pure O_2, 1 atm	100	100	100	100	100
Carbon Black Dispersion	ASTM D 3015	A1,A2,B1	A1,A2,B1	A1,A2,B1	A1,A2,B1	A1,A2,B1
Dimensional Stability (each direction), %	ASTM D 1204, 100 °C, 1 hr	±2	±2	±2	±2	±2
Melt Flow Index, g/10 minutes	ASTM D 1238, Cond.190/2.16	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0

GSE HD Textured is available in rolls approximately 22.5 ft (6.9 m) wide and weighing about 3,700 lb (1,678 kg). Other material thicknesses are available upon request.

[1]The combination of stress concentrations due to coextrusion texture geometry and the small specimen size results in large variation of test results. Therefore, these tensile properties are minimum average values.

[2]Note: ESCR for HD Textured is conducted on representative smooth membrane samples.

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GSE

GSE HyperFrictionFlex*
Textured HyperFlex* HDPE Geomembrane

GSE HyperFrictionFlex is a premium grade, high density polyethylene (HDPE) geomembrane produced from a specially formulated, virgin polyethylene resin, and textured using GSE's patented FrictionFlex® process. The polyethylene resin is designed specifically for flexible geomembrane applications. HyperFlex has outstanding resistance to UV radiation and stress cracking and is therefore highly suited for exposed applications. The FrictionFlex process is the only manufacturing method that provides a textured material without significant reduction of any of the physical properties of the smooth surfaced membrane. No other textured membrane provides an equivalent combination of enhanced slope stability and resistance to containment failure if settlement of the lined structure occurs.

TESTED PROPERTY	TEST METHOD	MINIMUM VALUES			
Thickness, mils (mm)	ASTM D 751/1593/5199	36 (0.90)	54 (1.35)	72 (1.80)	90 (2.25)
Density, g/cm^3	ASTM D 792/1505	0.94	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 638, Type IV				
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm	162 (28)	243 (43)	324 (57)	405 (71)
Strength at Yield, lb/in-width (N/mm)		86 (15)	130 (23)	173 (30)	216 (38)
Elongation at Break, %	G.L. = 2.5 in (64 mm)	500	560	560	560
Elongation at Yield, %	G.L. = 1.3 in (33 mm)	13	13	13	13
Tear Resistance, lb (N)	ASTM D 1004	30 (133)	45 (200)	60 (267)	75 (334)
Puncture Resistance, lb (N)	FTMS 101, Method 2065	52 (231)	80 (356)	105 (467)	130 (579)
Carbon Black Content, %	ASTM D 1603	2.0	2.0	2.0	2.0
Environmental Stress Crack Resistance, hr	ASTM D 1693, Cond. B	1500	1500	1500	1500

REFERENCE PROPERTY	TEST METHOD	NOMINAL VALUES			
Thickness, mils (mm)	ASTM D 751/1593/5199	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Roll Length (approximate), ft (m)		665 (216)	470 (215)	350 (107)	280 (85)
Low Temperature Brittleness, °F (°C)	ASTM D 746, Cond. B	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)	<-107 (<-77)
Oxidative Induction Time, minutes	ASTM D 3895, 200 °C Pure O_2, 1 atm	100	100	100	10
Carbon Black Dispersion	ASTM D 3015	A1,A2,B1	A1,A2,B1	A1,A2,B1	A1,A2,B1
Dimensional Stability (each direction), %	ASTM D 1204, 100 °C, 1 hr	±2	±2	±2	±2
Melt Flow Index, g/10 minutes	ASTM D 1238, Cond.190/2.16	≤1.0	≤1.0	≤1.0	≤1.0

GSE HyperFrictionFlex is available in rolls approximately 22.5 ft (6.9 m) and 24 ft (7.3 m) wide and weighing about 3,500 lb (1,588 kg). Other material thicknesses are available upon request. See the FrictionFlex Application Data Sheet for more information regarding the GSE FrictionFlex texturing process.

** Roll lengths correspond to the 24 ft (7.3 m) wide roll goods.

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DS 002 R03/04/98

GSE

GSE HyperNet*
HDPE Geonet

GSE HyperNet products are geosynthetic drainage materials composed of two bonded, overlapping HDPE strands commonly referred to as geonet. HyperNet transmits fluids (liquids and gases) in the plane of the net by creating open channels that allow flow. HyperNet is a premium grade geonet with excellent chemical resistance, mechanical properties and life expectancy.

GSE HyperNet HF*
HDPE High Flow Geonet

GSE HyperNet HF products are manufactured in the same manner as standard GSE HyperNet but are designed specifically for use in situations where high flow and high loads are expected such as in landfill cell designs.

GSE HyperNet CP*
HDPE Capping Geonet

GSE HyperNet CP products are manufactured in the same manner as standard GSE HyperNet but are designed specifically for use in situations where lower normal loads are expected such as in landfill cap designs.

TESTED PROPERTY	TEST METHOD	MINIMUM AVERAGE VALUES[d]		
		HyperNet	HyperNet HF	HyperNet CP
Transmissivity, m^2/sec	ASTM D 4716	1×10^{-3} [a]	2×10^{-3} [a]	1×10^{-3} [b]
Thickness, mil (mm)	ASTM D 5199	200 (5)	250 (6.3)	200 (5)
Density, g/cm^3	ASTM D 1505	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5034/5035	45 (7.9)	55 (9.6)	32 (5.6)
Carbon Black Content, %	ASTM D 1603	2.0	2.0	2.0
Roll Width, ft (m)		14 (4.3)	14 (4.3)	14 (4.3)
Roll Length[c] ft (m)		300 (90)	300 (90)	300 (90)

(a) Gradient of 1.0, normal load of 10,000 psf, water at 70°F between stainless steel plates
(b) Gradient of 1.0, normal load of 4,000 psf, water at 70°F between stainless steel plates
(c) Other roll lengths may be available upon request.
(d) These are typical values and are based on the cumulative results of specimens tested and as determined by GSE Quality Assurance practices

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Specifications

High Density Polyethylene (HDPE) – DS Textured

Series HTX13

Serrot's HDPE geomembranes are produced from first quality, high molecular weight resins and are manufactured specifically for containment of fluids in hydraulic structures. Serrot geomembranes are durable and have been formulated to be resistant to chemicals, ultraviolet degradation and leaching additives. The series of geomembranes shown below is based on a minimum average thickness value equal to the nominal thickness minus 5%, with the lowest individual of 8 of 10 values equal to the nominal thickness minus 10%, and the lowest individual of 10 values equal to nominal minus 15%.

Property	Test Method	Frequency[1]	HT413	HT613	HT813	HT1013
Thickness (nominal) (mils) Thickness (min. ave.) (mils) • Lowest indiv. of 8 of 10 values • Lowest indiv. of 10 values	D5994	per roll	40 38 36 34	60 57 54 51	80 76 72 68	100 95 90 85
Tensile Properties (min. ave.) • Yield Strength (lb/in) • Break Strength (lb/in) • Yield Elongation (%) • Break Elongation (%)	D638 Type IV (2 ipm) (1.3" gauge) (2.0" gauge)	50,000 SF	84 60 12 100	126 90 12 100	168 120 12 100	210 150 12 100
Tear Resistance (min. ave.) (lb)	D1004	50,000 SF	28	42	56	70
Puncture Resistance (min. ave.) (lb)	D4833 FTMS 101/ Method 2065[2]	50,000 SF Certified	60 52	90 78	120 104	150 130
Carbon Black Content (range) (%)	D1603/D4218	50,000 SF	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	D5596	50,000 SF	Note	Note	Note	Note
Density (min. ave.) (g/cc)	D1505/D792	Resin Batch	0.940	0.940	0.940	0.940
Stress Crack Resistance (hr)	D5397 (App.)	Resin Batch	200	200	200	200
Dimensional Stability (max. ave.) (%)	D1204	Resin Batch	±2	±2	±2	±2

[1] Testing frequencies are rounded to the nearest full roll.
[2] FTMS 101 has been replaced with D4833. Value shown for comparison purposes only. Carbon Black Dispersion for 10 different views: all 10 in Categories 1 or 2.

HTX13E 12/21/99

SERROT INTERNATIONAL, INC. 125 Cassia Way · Henderson, NV 89014 · 702-566-8600 · Fax: 702-566-4739 · Toll Free: 800-237-1777 www.serrot.com

GSE FabriCap*
HDPE Geonet/Geotextile Capping Composite

GSE FabriCap geocomposites typically consist of GSE HyperNet CP with nonwoven polypropylene geotextile fabric heat-bonded to one or both sides. The geotextile serves as a filter to prevent the geonet from clogging while the geonet provides a path for the fluids (liquids and gases). GSE HyperNet CP is manufactured in the same manner as standard GSE HyperNet but is designed specifically for use in situations where lower normal loads are expected such as in landfill cap designs.

TESTED PROPERTY	TEST METHOD	MINIMUM AVERAGE VALUES[e]		
		with 4 oz/yd²	with 6 oz/yd²	with 8 oz/yd²
Transmissivity[a] m²/sec	ASTM D 4716	1.1×10^{-4}	1.0×10^{-4}	9.0×10^{-5}
Ply Adhesion, lb/in (N/mm)	ASTM D 413 or F 904		See footnote (b)	
Roll Width, ft (m)		14 (4.3)	14 (4.3)	14 (4.3)
Roll Length, ft (m)		250 (76.2)	225 (68.6)	200 (60.9)
Net component only [c]				
Transmissivity[a] m²/sec	ASTM D 4716	1×10^{-3}	1×10^{-3}	1×10^{-3}
Thickness, mil (mm)	ASTM D 5199	200 (5)	200 (5)	200 (5)
Density, g/cm³	ASTM D 1505	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5034/5035	32 (5.6)	32 (5.6)	32 (5.6)
Carbon Black Content, %	ASTM D 1603	2.0	2.0	2.0
Geotextile component only [c,d]		**4 oz/yd²**	**6 oz/yd²**	**8 oz/yd²**
Thickness, mil (mm)	ASTM D 5199	45 (1.1)	60 (1.5)	80 (2.0)
Grab Tensile, lb (N)	ASTM D 4632	100 (445)	150 (665)	200 (890)
Puncture Strength, lb (N)	ASTM D 4833	65 (285)	95 (420)	130 (575)
AOS, US sieve (mm)	ASTM D 4751	70 (0.212)	70 (0.212)	80 (0.180)
Flow Rate, gpm/ft² (lpm/m²)	ASTM D 4491	140 (5700)	110 (4480)	110 (4480)
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	70	70	70

(a) Gradient of 1.0, normal load of 4,000 psf, water at 70°F between stainless steel plates
(b) Greater than the friction angle of the textile to soil
(c) Component properties prior to lamination
(d) Other geotextiles are available and may be provided as agreed upon by GSE. All geotextile property values are as reported by the geotextile supplier.
(e) These are typical values and are based on the cumulative results of specimens tested and as determined by GSE Quality Assurance practices

This information is provided for reference purposes only and is not intended as a warranty or guarantee. GSE assumes no liability in connection with the use of this information. Check with GSE for current, standard minimum quality assurance procedures.

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Represented by:

*For environmental lining solutions...the world comes to GSE.**
A Gundle/SLT Environmental, Inc. Company

Product Specification - Structural Geogrid UX160020SB

TensarEarthTechnologies.Inc.reservestherighttochange its product specifications at any time. It is the responsibility of the specifier and purchaser to ensure that product specifications used for design and procurement purposes are current and consistent with the products used in each instance. Please contact Tensar Earth Technologies, Inc. at 800-836-7271 for assistance

The structural geogrid shall be an integrally formed grid structure manufactured of a stress resistant high density polyethylene material with molecular weight and molecular characteristics which impart: (a) high resistance to loss of load capacity or structural integrity when the geogrid is subjected to mechanical stress in installation; (b) high resistance to deformation when the geogrid is subjected to applied force in use; and (c) high resistance to loss of load capacity or structural integrity when the geogrid is subjected to long-term environmental stress.

The structural geogrid shall accept applied force in use by positive mechanical interlock (i.e. by direct mechanical keying) with: (a) compacted soil or construction fill materials; (b) contiguous sections of itself when overlapped and embedded in compacted soil or construction fill materials; and (c) rigid mechanical connectors such as bodkins, pins or hooks. The structural geogrid shall possess sufficient cross sectional profile to present a substantial abutment interface to compacted soil or particulate construction fill materials and to resist movement relative to such materials when subject to applied force. The structural geogrid shall possess sufficient true initial modulus to cause applied force to be transferred to the geogrid at low strain levels without material deformation of the reinforced structure. The structural geogrid shall possess complete continuity of all properties throughout its structure and shall be suitable for reinforcement of compacted soil or particulate construction fill materials to improve their long term stability in structural load bearing applications such as earth retention systems. The structural geogrid shall otherwise have the following characteristics:

Product Type	**- Integrally Formed Structural Geogrid**
Load Transfer Mechanism	**- Positive Mechanical Interlock**

Product Properties	**Units**	**MD Values**[1]
Load Capacity		
· True Initial Modulus in Use[2]	kN/m (lb/ft)	1787.3 (122,500)
· Long-Term Allowable Load In Sands, Silts & Clay[3]	kN/m (lb/ft)	41.7 (2,857)
· Long-Term Allowable Load In Well Graded Sand[3]	kN/m (lb/ft)	41.7 (2,857)
· Long-Term Allowable Load in Aggregate[3]	kN/m (lb/ft)	37.4 (2,564)
Integrity of Product Structure		
· Junction Strength[4]	kN/m (lb/ft)	100.8 (6,908)
· Flexural Stiffness[5]	x1,000 mg-cm	6,600

Durability

· Resistance to Installation Damage[6]	%SC/%SW/%GP	95/95/85
· Resistance to Long-Term Degradation[7]	%	100

Dimensions and Delivery

The structural geogrid shall be delivered to the jobsite in roll form with each roll individually identified and nominally measuring 1.3 meters (4.26 feet) in width and 61.0 meters (200 feet) in length. A typical truckload quantity is 216 rolls. On special request, the structural geogrid may also be custom cut to specific lengths or widths to suit site specific engineering designs.

Notes

1. Unless indicated otherwise, values shown are minimum average roll values determined in accordance with ASTM D-4759. Brief descriptions of test procedures are given in the following notes. Complete descriptions of test procedures are available on request from Tensar Earth Technologies, Inc.
2. True resistance to elongation when initially subjected to a load measured via GRI-GG1 (tested at 10 percent per minute based on the greater of 2 aperture or 8-inch [200 millimeter] gauge length) without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.
3. True strength available for resisting force in long-term load bearing applications is determined by reducing ultimate tensile strength by state-of-practice factors for installation damage, degradation in use, product integrity limitations and long-term product deformation per GRI-GG4.
4. Load transfer capability measured via GRI-GG2.
5. Resistance to bending force measured via ASTM D-1388, Option A, using specimen dimensions of 864 millimeters in length by 1 aperture in width.
6. Resistance to loss of load capacity or structural integrity when subjected to mechanical stress in installation measured via ASTM D-5818 in a clayey sand (SC), a well graded sand (SW) and crushed stone classified as a poorly graded gravel with a maximum 2 inch particle size (GP).
7. Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments measured via EPA 9090 immersion testing.

Tensar Earth Technologies, Inc.
5775-B Glenridge Drive
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Atlanta, Georgia 30328-5363
(800) 836-7271

Date: June 1, 1999

This product specification supersedes all prior specifications for the product described above and is not applicable to any products shipped to jobsite prior to June 1, 1999.

SERROT INTERNATIONAL, INC.

[Up]

BENTOFIX®

Thermal Lock "NSL" Geosynthetic Clay Liner	FIX - 501 NSL

· Technical Bulletin ·

Bentofix Thermal Lock "NSL" is a needlepunch reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a slit-film woven and a virgin staple fiber nonwoven geotextile. The needlepunched fibers are thermally fused to the woven geotextile to enhance the reinforcing bond.

Geotextile Properties	Test Method	Minimum Test Frequency	Value - English	Value - SI
Cap Nonwoven Mass/Unit Area	ASTM D 5261	1/200,000 sq. ft (1/20,000 sq. m)	6.0 oz./yd^2 MARV	200 g / m^2 MARV
Woven Scrim Mass/Unit Area	ASTM D 5261	1/200,000 sq. ft (1/20,000 sq. m)	3.1 oz./yd^2 MARV	105 g / m^2 MARV
Bentonite Properties				
Swell Index	ASTM D 5890	1/100,000 lbs. (50,000 kg)	24 ml / 2g min.	24 ml / 2g min.
Moisture Content	ASTM D 4643	1/100,000 lbs. (50,000 kg)	12 % max.	12 % max.
Fluid Loss	ASTM D 5891	1/100,000 lbs. (50,000 kg)	18 ml max.	18 ml max.
Finished GCL Properties				
Bentonite Mass Per Unit Area[1]	ASTM D 5993	1/40,000 sq. ft (1/4,000 sq. m)	0.75 lb. / sq. ft MARV	3.66 kg / m^2 MARV
Grab Strength[2]	ASTM D 4632	1/40,000 sq. ft (1/4,000 sq. m)	95 lbs MARV	422 N MARV
Grab Elongation[2]	ASTM D 4632	1/40,000 sq. ft (1/4,000 sq. m)	100 % Typical	100 % Typical
Peel Strength[3]	ASTM D 4632	1/40,000 sq. ft (1/4,000 sq. m)	15 lbs. min.	66 N
Permeability[4]	ASTM D 5084	1/100,000 sq. ft (1/10,000 sq. m)	5 x 10^{-9} cm/sec max	5 x 10^{-9} cm/sec max
Index Flux[4]	ASTM D 5887	1/Week	1 x 10^{-8} m^3/m^2/sec max	1 x 10^{-8} m^3/m^2/sec max

Internal Shear Strength[5]	ASTM D 6243	Periodic	500 psf Typical	24 kPa Typical
Dimensions				
Width x Length	nominal	Every Roll	15.5 x 150 ft	4.7 x 45.72 m
Area per Roll	nominal	Every Roll	2325 ft^2	216 m^2
Packaged Weight	typical	Every Roll	2160 lbs	980 kg

NOTES:

1. Oven-dried measurement. Equates to .084 lb when indexed to a 12% moisture content.
2. Measured at maximum peak, in the weakest principal direction.
3. Modified to use a 4-inch wide grip. The maximum peak of five specimens averaged.
4. De-Aired Tap Water @ 5 psi maximum effective confining stress and 2 psi head.
5. Typical peak value for specimen hydrated for 24 hr. and sheared under a 200 psf normal stress.

BFNSL - 0599

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TENAX **CE**

Type: **450 - 600 - 750 - 900**

Geonets

TENAX **CE** geonets are high profile rhomboidal shaped mesh structures made by two sets of overlaid intersecting strands. The intersecting strands form overlaid sets of continuous deep channels which provide high flow capacity. These geonets are used in waste disposal and general civil engineering projects, where a high flow capacity is required.
TENAX **CE** geonets are manufactured from extrusion of High Density Polyethylene (HDPE), black in color; they are inert to chemical and biological conditions normally occurring in soil. Moreover they are treated with special additives to resist UV degradation.
TENAX **CE** geonets are available in a wide range of thicknesses and widths, so as to satisfy any design and installation need.

Typical applications

Load distribution, site leveling and mechanical protection of the geomembrane; drainage of the accidental leaks below primary; leachate and rain water collection above primary geomembrane; mechanical protection of the geomembranes when in contact with waste-materials and/or soil; drainage of liquids and gases present in the soil above and/or below the capping geomembrane.

PHYSICAL CHARACTERISTICS		**CE 450**	**CE 600**	**CE 750**	**CE 900**	**notes**
STRUCTURE		2 strands	2 strands	2 strands	2 strands	
POLYMER TYPE		HDPE	HDPE	HDPE	HDPE	
U.V. STABILIZER		carbon black	carbon black	carbon black	carbon black	
FOAMING AGENT		NO	NO	NO	NO	

DIMENSIONAL CHARACTERISTICS	**UNIT**	**CE 450**	**CE 600**	**CE 750**	**CE 900**	**notes**
THICKNESS at 20 kPa	mm	4.0	4.5	5.0	5.5	a,c
THICKNESS at 200 kPa	mm	3.8	4.2	4.8	5.2	a,c
UNIT WEIGHT	g/m^2	450	600	750	900	a,d
ROLL WIDTH	m	2.3	2.3	2.3	2.3	a,g
ROLL LENGTH	m	100	50	50	50	a
ROLL DIAMETER	m	0.78	0.56	0.58	0.62	a
ROLL VOLUME	m^3	1.41	0.73	0.79	0.89	a
ROLL GROSS WEIGHT	kg	103.5	69.0	86.3	103.5	a

TECHNICAL CHARACTERISTICS	**UNIT**	**CE 450**	**CE 600**	**CE 750**	**CE 900**	**notes**
HYDRAULIC FLOW RATE						
i=1 σv = 20 kPa	m^2/ sec	1.18 E-03	1.39 E-03	1.41 E-03	1.44 E-03	a,b,e
i=1 σv = 100 kPa	m^2/ sec	1.11 E-03	1.31 E-03	1.33 E-03	1.36 E-03	a,b,e
i=1 σv = 200 kPa	m^2/ sec	1.00 E-03	1.24 E-03	1.26 E-03	1.28 E-03	a,b,e
i=1 σv = 500 kPa	m^2/ sec	3.84 E-04	7.61 E-04	9.26 E-04	1.09 E-03	a,b,e
TENSILE STRENGTH	kN / m	4.0	5.0	7.0	9.0	a,b,f
ELONGATION AT PEAK	%	80	30	30	30	a,b,f

NOTES:
a) *Typical values*
b) Longitudinal direction
c) *ISO 9863*
d) ISO 9864
e) ASTM D4716
f) ISO 10319
g) *Upon request available 3.8 m wide*

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Man, Technology, Environment.

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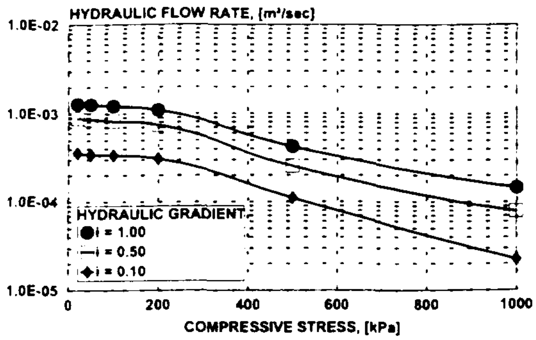
Typical Hydraulic Characteristics

TENAX CE 450



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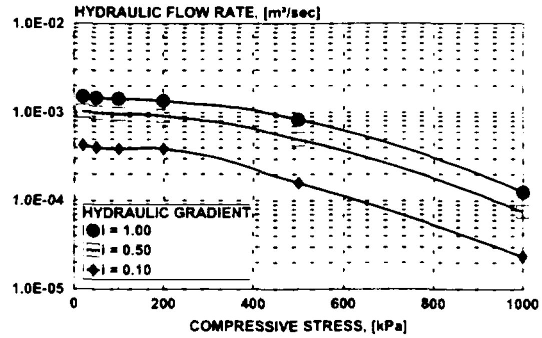
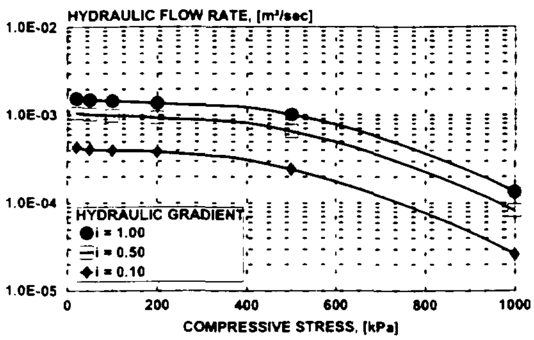
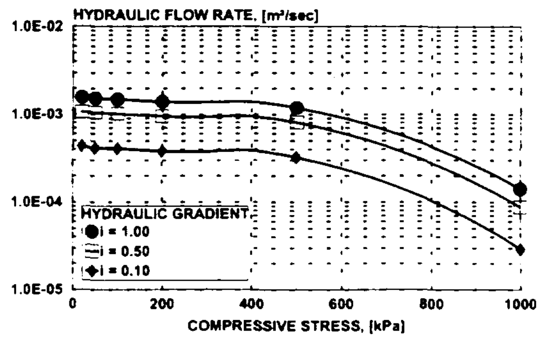
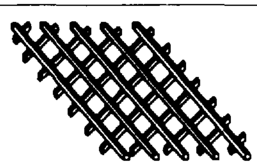


TENAX CE 750



TENAX CE 900





TENAX CE

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TENAX **CE**

Type: **1000**

Geonet

TENAX **CE** geonets are high profile rhomboidal shaped mesh structures made by two sets of overlaid intersecting strands. The intersecting strands form overlaid sets of continuous deep channels which provide high flow capacity. These geonets are used in waste disposal and general civil engineering projects, where a high flow capacity is required.

TENAX **CE** geonets are manufactured from extrusion of High Density Polyethylene (HDPE), black in color; they are inert to chemical and biological conditions normally occurring in soil. Moreover they are treated with special additives to resist UV degradation.

TENAX **CE** geonets are available in a wide range of thicknesses and widths, so as to satisfy any design and installation need.

The TENAX **CE 1000** geonet is ideal for mechanical protection of the geomembrane. Its structure, having a small mesh, high unit weight and cover properties, avoid the damages of the waterproofing geomembranes due to sharp objects and concentrated loads.

Typical applications

Load distribution, site leveling and mechanical protection of the geomembrane; drainage of the accidental leaks below primary; leachate and rain water collection above primary geomembrane; mechanical protection of the geomembranes when in contact with waste-materials and/or soil; drainage of liquids and gases present in the soil above and/or below the capping geomembrane.

PHYSICAL CHARACTERISTICS	**TEST METHOD**	**UNIT**	**CE 1000**	**notes**
STRUCTURE			2 strands	
POLYMER TYPE			HDPE	
U.V.STABILIZER			carbon black	
FOAMING AGENT			NO	

DIMENSIONAL CHARACTERISTICS	**TEST METHOD**	**UNIT**	**CE 1000**	**notes**
THICKNESS at 20 kPa	ISO 9863	mm	4.0	a
THICKNESS at 200 kPa	ISO 9863	mm	3.8	a
UNIT WEIGHT	ISO 9864	g/m^2	1000	a
MD APERTURE SIZE		mm	5.0	a,b
TD APERTURE SIZE		mm	5.0	a,c
ROLL WIDTH		m	2.0	a
ROLL LENGTH		m	25	a
ROLL DIAMETER		m	0.39	a
ROLL VOLUME		m^3	0.31	a
ROLL GROSS WEIGHT		kg	50.0	a

TECHNICAL CHARACTERISTICS	**TEST METHOD**	**UNIT**	**CE 1000**	**notes**
HYDRAULIC FLOW RATE				
i = 1.00 σv = 20 kPa	ASTM D4716	m^2/s	1.09 E-03	a,b
i = 1.00 σv = 100 kPa	ASTM D4716	m^2/s	1.04 E-03	a,b
i = 1.00 σv = 200 kPa	ASTM D4716	m^2/s	9.81 E-04	a,b
i = 1.00 σv = 500 kPa	ASTM D4716	m^2/s	4.12 E-04	a,b
TENSILE STRENGTH	ISO 10319	kN/m	8.5	a,b
ELONGATION AT PEAK	ISO 10319	%	40	a,b
RESIDUAL THICKNESS at 100 kPa	ASTM D1621	%	> 95	a
RESIDUAL THICKNESS at 500 kPa	ASTM D1621	%	> 70	a

NOTES:
a) *Typical values*
b) Machine direction (MD)
c) Transversal direction (TD)

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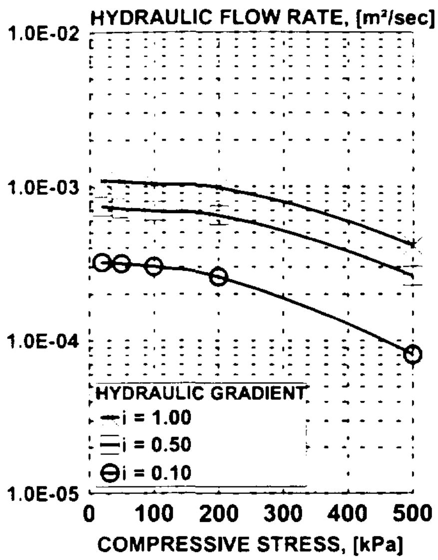
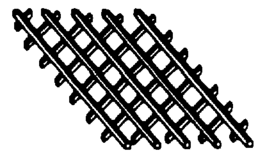
Typical Hydraulic Characteristics

TENAX CE 1000





TENAX CE

The TENAX Laboratory has been created in 1980 and has been continuously improved with the purpose of assuring unequalled technical development of the products and accurate Quality Control

The TENAX Laboratory can perform mechanical, hydraulic and durability tests, according to the most important international standards like ISO CEN ASTM DIN BSI UNI

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Man, Technology, Environment.

Bentomat® DN Certified Properties

Bentomat "DN" is a reinforced GCL consisting of a layer of sodium bentonite between two geotextiles, which are needlepunched together.

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY, ft^2 (m^2)	CERTIFIED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tons	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tons	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2)
GCL Grab Strength[3]	ASTM D 4632	200,000 ft^2 (20,000 m^2)	150 lbs (400 N)
GCL Peel Strength[3]	ASTM D 4632	40,000 ft^2 (4,000 m^2)	15 lbs (65 N)
GCL Index Flux[4]	ASTM D 5887	Weekly	1×10^{-8} $m^3/m^2/sec$
GCL Permeability[4]	ASTM D 5084	Weekly	5×10^{-9} cm/sec
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321	Periodic	500 psf (24 kPa) typical

Notes:

1 Bentonite property tests performed at CETCO's bentonite processing facility before shipment to CETCO's GCL production facilities.

2 Bentonite mass/area reported at 0 percent moisture content.

3 All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.

4 Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5×10^{-9}cm/sec for typical GCL thickness. This flux value should not be used for equivalency calculations unless the gradients used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.

5 Peak value measured at 200 psf (10 kPa) normal stress. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

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over

Bentomat® DN Panel and Roll Specifications

STANDARD PANEL SPECIFICATIONS

Panel Dimensions*........................**14** ft. (**4.3** m) wide; **150** ft. (**45.7** m) long
Total Panel Area...........................**2,100** sq. ft. (**195** sq. m)
Effective Area..............................**1,998** sq. ft. (**185** sq. m)
{Assumes 6-in. (150 mm) edge overlap and 2-ft. (600 mm) end overlap}

STANDARD ROLL SPECIFICATIONS

Dimensions.................................**16** ft. (**4.88** m) wide w/ core; **24** in. (**610** mm) diameter
Nominal Weight...........................**2,600** lbs. (**1,180** kg)
Core Size (I.D.)............................**4** in. (**100** mm) I.D. Inner core plug measures **2.5** in. (**63** mm)
Packaging...................................**8**-mil (**0.2** mm) U.V.-resistant polyethylene sleeve

STANDARD SHIPPING SPECIFICATIONS

Shipment Size.............................**15** rolls per truckload or container load
Granular Bentonite.......................**50**-lb. (**23** kg) bags

UNLOADING AND HANDLING EQUIPMENT

Core Pipe and Spreader Bar............**18** ft. (**5.5** m) long, **2.5** in. (**63** mm) Nominal Pipe Size, XXH
OR: Solid steel pipe
OR: Stinger attachment for forklift
Chains or Straps...........................**2** required; each approximately **12** ft. (**3.7** m) long
Equipment..................................Front end loader or forklift (typical)

* Custom lengths/widths available

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Bentomat® ST Certified Properties

Bentomat "ST" is a reinforced GCL consisting of a layer of sodium bentonite between woven and non-woven geotextiles, which are needlepunched together.

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY, ft^2 (m^2)	CERTIFIED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tons	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tons	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2)
GCL Grab Strength[3]	ASTM D 4632	200,000 ft^2 (20,000 m^2)	90 lbs (400 N)
GCL Peel Strength[3]	ASTM D 4632	40,000 ft^2 (4,000 m^2)	15 lbs (65 N)
GCL Index Flux[4]	ASTM D 5887	Weekly	1×10^{-8} $m^3/m^2/sec$
GCL Permeability[4]	ASTM D 5084	Weekly	5×10^{-9} cm/sec
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321	Periodic	500 psf (24 kPa) typical

Notes:

1 Bentonite property tests performed at CETCO's bentonite processing facility before shipment to CETCO's GCL production facilities.

2 Bentonite mass/area reported at 0 percent moisture content.

3 All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.

4 Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5×10^{-9}cm/sec for typical GCL thickness. This flux value should not be used for equivalency calculations unless the gradients used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.

5 Peak value measured at 200 psf (10 kPa) normal stress. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

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Bentomat® ST Panel and Roll Specifications

STANDARD PANEL SPECIFICATIONS

Panel Dimensions*........................**15** ft. (**4.6** m) wide; **150** ft. (**45.7** m) long
Total Panel Area............................**2,250** sq. ft. (**209** sq. m)
Effective Area...............................**2,145** sq. ft. (**200** sq. m)
{Assumes 6-in. (150 mm) edge overlap and 2-ft. (600 mm) end overlap}

STANDARD ROLL SPECIFICATIONS

Dimensions..................................**16** ft. (**4.88** m) wide w/ core; **24** in. (**610** mm) diameter
Nominal Weight............................**2,700** lbs. (**1,225** kg)
Core Size (I.D.).............................**4** in. (**100** mm) I.D. Inner core plug measures **2.5** in. (**63** mm)
Packaging....................................**8**-mil (**0.2** mm) U.V.-resistant polyethylene sleeve

STANDARD SHIPPING SPECIFICATIONS

Shipment Size..............................**15** rolls per truckload or container load
Granular Bentonite........................**50**-lb. (**23** kg) bags

UNLOADING AND HANDLING EQUIPMENT

Core Pipe and Spreader Bar............**18** ft. (**5.5** m) long, **2.5** in. (**63** mm) Nominal Pipe Size, XXH
OR: Solid steel pipe
OR: Stinger attachment for forklift
Chains or Straps............................**2** required; each approximately **12** ft. (**3.7** m) long
Equipment....................................Front end loader or forklift (typical)

* Custom lengths/widths available

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Bentomat® CL Certified Properties

Bentomat "CL" is a reinforced GCL consisting of a layer of sodium bentonite between two geotextiles, which are needlepunched together and laminated to a thin flexible membrane liner.

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY, ft^2 (m^2)	CERTIFIED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tons	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tons	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2)
GCL Grab Strength[3]	ASTM D 4632	200,000 ft^2 (20,000 m^2)	120 lbs (530 N)
GCL Peel Strength[3]	ASTM D 4632	40,000 ft^2 (4,000 m^2)	15 lbs (65 N)
GCL Index Flux[4]	ASTM D 5887 or E 96	Weekly	1×10^{-9} m^3/m^2/sec
GCL Hydraulic Conductivity[4]	ASTM D 5084 or E 96	Weekly	5×10^{-10} cm/sec
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321	Periodic	500 psf (24 kPa) typical

Notes:

1 Bentonite property tests performed at CETCO's bentonite processing facility before shipment to CETCO's GCL production facilities.

2 Bentonite mass/area reported at 0 percent moisture content.

3 All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.

4 ASTM D5887 Index flux and ASTM D5084 hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 95 gal/acre/day. This flux value is equivalent to a permeability of 5×10^{-10} cm/sec for typical GCL thickness. Alternatively, hydraulic conductivity can be determined by performing water vapor transmissivity testing (ASTM E 96) on the membrane side of the GCL and use conversion outlined by Koerner (1994). This flux value should not be used for equivalency calculations unless the gradients used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.

5 Peak value measured at 200 psf (10 kPa) normal stress. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

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Bentomat® CL Panel and Roll Specifications

STANDARD PANEL SPECIFICATIONS

Panel Dimensions*........................**14.5** ft. (**4.4** m) wide; **150** ft. (**45.7** m) long
Total Panel Area............................**2,175** sq. ft. (**202** sq. m)
Effective Area...............................**2,072** sq. ft. (**192.5** sq. m)
{Assumes 6-in. (150 mm) edge overlap and 2-ft. (600 mm) end overlap}

STANDARD ROLL SPECIFICATIONS

Dimensions..................................**16** ft. (**4.88** m) wide w/ core; **24** in. (**610** mm) diameter
Nominal Weight............................**2,700** lbs. (**1,225** kg)
Core Size (I.D.).............................**4** in. (**100** mm) I.D. Inner core plug measures **2.5** in. (**63** mm)
Packaging....................................**8**-mil (**0.2** mm) U.V.-resistant polyethylene sleeve

STANDARD SHIPPING SPECIFICATIONS

Shipment Size..............................**15** rolls per truckload or container load
Granular Bentonite.......................**50**-lb. (**23** kg) bags

UNLOADING AND HANDLING EQUIPMENT

Core Pipe and Spreader Bar............**18** ft. (**5.5** m) long, **2.5** in. (**63** mm) Nominal Pipe Size, XXH
OR: Solid steel pipe
OR: Stinger attachment for forklift
Chains or Straps............................**2** required; each approximately **12** ft. (**3.7** m) long
Equipment....................................Front end loader or forklift (typical)

* Custom lengths/widths available

Claymax® 200R Certified Properties

Claymax "200R" is an unreinforced GCL consisting of a layer of sodium bentonite between two woven geotextiles, which are continuously adhered together.

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY, ft^2 (m^2)	CERTIFIED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tons	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tons	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2)
GCL Grab Strength[3]	ASTM D 4632	200,000 ft^2 (20,000 m^2)	150 lbs (660 N)
GCL Peel Strength	ASTM D 4632	N/A	N/A
GCL Index Flux[4]	ASTM D 5887	Weekly	1×10^{-8} $m^3/m^2/sec$
GCL Permeability[4]	ASTM D 5084	Weekly	5×10^{-9} cm/s
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321	Periodic	50 psf (2.4 kPa) typical

Notes:

1 Bentonite property tests performed at CETCO's bentonite processing facility before shipment to CETCO's GCL production facilities.

2 Bentonite mass/area reported at 0 percent moisture content.

3 All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.

4 Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5×10^{-9} cm/sec for typical GCL thickness. This flux value should not be used for equivalency calculations unless the gradients used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.

5 Peak value measured at 200 psf (10 kPa) normal stress. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

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Claymax® 200R Panel and Roll Specifications

STANDARD PANEL SPECIFICATIONS

Panel Dimensions*........................**13.8** ft. (**4.2** m) wide; **150** ft. (**45.7** m) long
Total Panel Area...........................**2,075** sq. ft. (**193** sq. m)
Effective Area..............................**1,973** sq. ft. (**183** sq. m)
{Assumes 6-in. (150 mm) edge overlap and 2-ft. (600 mm) end overlap}

STANDARD ROLL SPECIFICATIONS

Dimensions.................................**14.5** ft. (**4.4** m) wide w/ core; **20** in. (**510** mm) diameter
Nominal Weight...........................**2,600** lbs. (**1,180** kg)
Core Size....................................**4** in. (**100** mm) I.D. Inner core plug measures 2.5 in. (**63** mm)
Packaging...................................**8**-mil (**0.2** mm) U.V.-resistant polyethylene sleeve

STANDARD SHIPPING SPECIFICATIONS

Shipment Size.............................**15** rolls per truckload

UNLOADING AND HANDLING EQUIPMENT

Core Pipe and Spreader Bar...........**16** ft. (**4.3** m) long, **3.5** in. (**89** mm) O.D., XXH
OR: Solid steel pipe
OR: Stinger attachment for forklift
Chains or Straps...........................**2** required; each approximately **12** ft. (**3.7** m) long
Equipment...................................Front end loader or forklift (typical)

* Custom lengths/widths available

Claymax® 600CL Certified Properties

Claymax "600CL" is an unreinforced GCL consisting of a layer of sodium bentonite between a geotextile and a laminate comprised of a geotextile and a polyethylene membrane, which are continuously adhered together.

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY, ft^2 (m^2)	CERTIFIED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tons	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tons	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2)
GCL Grab Strength[3]	ASTM D 4632	200,000 ft^2 (20,000 m^2)	75 lbs (330 N)
GCL Peel Strength	ASTM D 4632	N/A	N/A
GCL Index Flux[4]	ASTM D 5887 or E96	Weekly	1 x 10^{-9} m^3/m^2/sec
GCL Permeability[4]	ASTM D 5084 or E96	Weekly	5 x 10^{-10} cm/s
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321	Periodic	50 psf (2.4 kPa) typical

Notes:

1 Bentonite property tests performed at CETCO's bentonite processing facility before shipment to CETCO's GCL production facilities.

2 Bentonite mass/area reported at 0 percent moisture content, the GCL industry standard.

3 All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.

4 Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 95 gal/acre/day. This flux value is equivalent to a permeability of 5x10^{-10} cm/sec for typical GCL thickness. Alternatively, hydraulic conductivity can be determined by performing water vapor transmissivity testing (ASTM E96) on the membrane side of the GCL and use conversion outlined by Koerner (1994). This flux value should not be used for equivalency calculations unless the gradients used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior to the end of the production date of the supplied GCL may be provided.

5 Peak value measured at 200 psf (10 kPa) normal stress. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

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Claymax® 600CL Panel and Roll Specifications

STANDARD PANEL SPECIFICATIONS

Panel Dimensions*........................**13.8** ft. (**4.2** m) wide; **150** ft. (**45.7** m) long

Total Panel Area............................**2,075** sq. ft. (**193** sq. m)

Effective Area...............................**1,973** sq. ft. (**183** sq. m)

{Assumes 6-in. (150 mm) edge overlap and 2-ft. (600 mm) end overlap}

STANDARD ROLL SPECIFICATIONS

Dimensions.................................**14.5** ft. (**4.4** m) wide w/ core; **20** in. (**510** mm) diameter

Nominal Weight............................**2,700** lbs. (**1,225** kg)

Core Size....................................**4** in. (**100** mm) I.D. Inner core plug measures 2.5 in. (**63** mm)

Packaging...................................**8**-mil (**0.2** mm) U.V.-resistant polyethylene sleeve

STANDARD SHIPPING SPECIFICATIONS

Shipment Size..............................**15** rolls per truckload

UNLOADING AND HANDLING EQUIPMENT

Core Pipe and Spreader Bar............**16** ft. (**4.3** m) long, **3.5** in. (**89** mm) O.D., XXH

OR: Solid steel pipe

OR: Stinger attachment for forklift

Chains or Straps............................**2** required; each approximately **12** ft. (**3.7** m) long

Equipment...................................Front end loader or forklift (typical)

* Custom lengths/widths available

APPENDIX I

TECHNICAL INFORMATION ON PERFORMANCE OF GEOSYNTHETIC CLAY LINERS

96-4 Bonaparte, R., Othman, M.A., Rad, N.S., Swan, R.H., and Vander Linde, D.L., "Evaluation of Various Aspects of GCL Performance", Appendix F in *Report of 1995 Workshop on Geosynthetic Clay Liners*, D.E. Daniel and H.B. Scranton authors, EPA/600/R-96/149, USEPA National Risk Management Research Laboratory, Cincinnati, 1996, pp. F1-F34.

EVALUATION OF VARIOUS ASPECTS OF GCL PERFORMANCE

by

R. Bonaparte[1], M.A. Othman[1], N.R. Rad[1], R.H. Swan[1], and D.L. Vander Linde[1]

INTRODUCTION

The purpose of this paper is to briefly present the results of various activities that have recently been undertaken by the authors on the subject of geosynthetic clay liner (GCL) testing and performance evaluation. The subjects that are addressed are:

- field hydraulic performance of composite liners containing GCLs;
- drained shear strength of hydrated GCLs at high normal stress;
- interface shear strength between unhydrated GCLs and textured geomembranes at high normal stress;
- hydration of GCLs adjacent to soil layers; and
- causes of failure of a landfill cover system containing a GCL.

FIELD PERFORMANCE OF COMPOSITE LINERS CONTAINING GCLs

Sources of Flow in LDS of Double-Liner System

A double liner system consists of top and bottom liners with a leakage detection system (LDS) between the two liners. If the double-liner system is used in a landfill, it will also contain a leachate collection and removal system (LCRS) above the top liner. As part of an ongoing research investigation for the United States Environmental Protection Agency (USEPA), the authors have collected data

[1]GeoSyntec Consultants, 1100 Lake Hearn Drive, Atlanta, Georgia 30342

on the rates of liquid flow into the sumps of LCRSs and LDSs for a wide variety of, double-lined waste management units located throughout the United States. Comparison of the rates of flow into the LCRS and LDS of a unit can be used to quantify the performance of the top liner (in terms of the ability to impede advective transport of liquid through the liner). In essence, the LDS serves as a large lysimeter (i.e., collection pan) below the top liner.

To make the evaluation, consideration must be given to the potential sources of liquid in the LDS. Gross et al. [1990] described the potential sources of LDS flow, which are (Figure 1): (i) leakage through the top liner; (ii) drainage of water (mostly rainwater) that infiltrates the leakage detection layer during construction but does not drain to the LDS sump until after start of facility operation ("construction water"); (iii) water expelled from the LDS layer as a result of compression under the weight of the waste ("compression water"); (iv) water expelled from any clay component of the top liner as a result of clay consolidation under the weight of the waste ("consolidation water"); and (v) for a waste management unit with its base located below the water table, groundwater infiltration through the bottom liner ("infiltration water").

Gross et al. [1990] and Bonaparte and Gross [1990] presented the following five-step approach for evaluating the sources of LDS liquid at a specific waste management unit.

- Identify the potential sources of flow for the unit based on double-liner system design, climatic and hydrogeologic setting, and unit operating history.

- Calculate flow rates from each potential source.

- Calculate the time frame for flow from each potential source.

- Evaluate the potential sources of flow by comparing measured flow rates to calculated flow rates at specific points in time.

- Compare LCRS and LDS chemical constituent data to further establish the likely source(s) of liquid.

Bonaparte and Gross [1990, 1993] used this five-step approach to evaluate the sources of LDS flow for 93 waste management units. Under a contract to the USEPA Risk Reduction Research Laboratory, the authors are currently performing this evaluation using new data from the facilities in the Bonaparte and Gross studies, as well as data from a significant number of additional waste management units not included in the original studies. Preliminary results for waste management units with composite top liners containing GCLs are presented below.

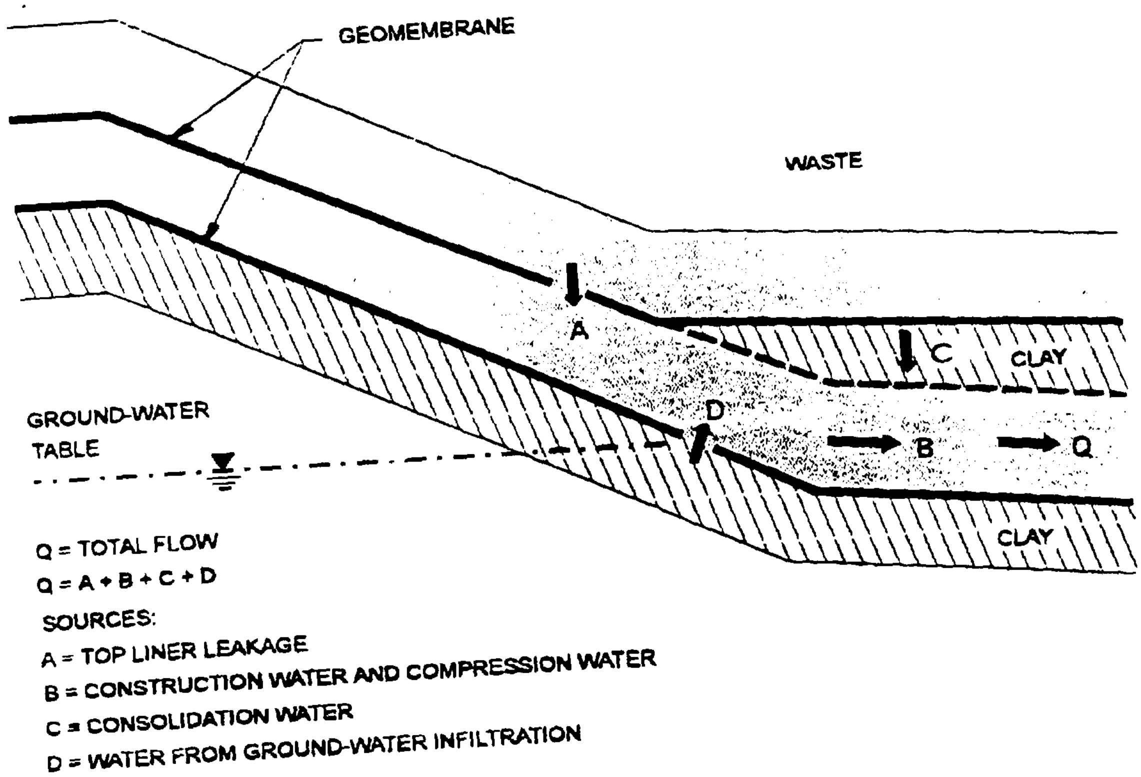

Figure 1. Sources of flow from leak detection layers.

LCRS and LDS Flow Data

Flow rate data have been collected for 26 waste management units containing composite top liners consisting of a geomembrane overlying a GCL. The 26 units are located at six different landfill sites. Descriptions of the components of the liner systems used at these facilities are presented in Table 1 and flow rate data for the LCRSs and LDSs in the units are presented in Table 2. Average daily flow rates were calculated for both systems on a monthly basis by dividing the total amount of liquid extracted from the system during the month by the number of days in the month and the area of the waste management unit. Flow rates are reported in units of liter/hectare/day (lphd). The volume of flow used in the calculation was typically obtained from the landfill operator, with flow measurements most often measured using accumulating flow meters. The reported flow volumes should be considered approximate.

Table 1. Description of landfill liner system components.

Landfill Identification	LCRS		Composite Top Liner		LDS		Bottom Liner		
	Material	Thickness (mm)	HDPE Geomembrane Thickness (mm)	GCL Thickness (mm)	Material	Thickness (mm)	HDPE Geomembrane Thickness (mm)	Layer 2	
								Material	Thickness (mm)
A	Sand	600	1.5	13	Sand	300	1.5	Clay	200
B	Sand	600	2.0	13	Sand	450	2.0	Clay	300
C	Sand	450	1.5	13	Sand	300	1.5	GCL	13
D	Sand	600	1.5	13	GT/GN[1]	5	1.5	N/A	N/A
E	Sand	600	1.5	13	GT/GN	5	1.5	Clay	900
F	GN	5	1.5	13	GT/GN	5	1.0	GCL	13

Notes: [1] GT= Geotextile, GN= Geonet.
[2] All material thicknesses are nominal values.

Table 2. Summary of flow data for the LCRS and LDS of units with composite top liners containing GCLs.

Cell No.	Cell Area (hectare)	End of Cell Const. (month-year)	Start of Waste Placem. (month-year)	End of Final Closure (month-year)	Initial Period of Operation[1] Time Period (months)	Initial LCRS Flow[4] Avg. (lphd)	Initial LCRS Flow Peak (lphd)	Initial LDS Flow Avg. (lphd)	Initial LDS Flow Peak (lphd)	Active Period of Operation[2] Time Period (months)	Active LCRS Flow Avg. (lphd)	Active LCRS Flow Peak (lphd)	Active LDS Flow Avg. (lphd)	Active LDS Flow Peak (lphd)	Post Closure Period[3] Time Period (months)	Post LCRS Flow Avg. (lphd)	Post LCRS Flow Peak (lphd)	Post LDS Flow Avg. (lphd)	Post LDS Flow Peak (lphd)
A1	2.0	7-88	7-88	2-91	1-2	16,718	19,738	0.0	0.0	3-32	561	2,384	0.0	0.0	33-83	65	103	0.0	0.0
A2	2.0	7-88	7-88	2-91	1-5	15,521	58,671	15.0	44.9	6-32	281	570	1.9	20.6	33-83	178	421	0.0	0.0
A3	1.7	8-88	9-88	4-93	1-5	3,366	7,985	34.6	150.5	6-56	290	1,075	3.7	46.8	57-81	206	458	0.9	9.4
A4	1.7	8-88	9-88	4-93	1-12	2,534	12,688	101.0	860.2	13-56	75	187	0.9	13.1	57-81	47	84	0.0	0.0
A5	2.8	9-88	10-88		1-11	1,384	3,394	37.4	91.6	12-80	56	187	1.9	37.4					
A6	3.9	11-88	12-88		1-9	3,759	7,171	53.3	92.6	10-80	168	655	0.0	0.0					
A7	2.6	1-89	2-89		1-10	5,376	12,155	33.7	46.8	11-76	234	851	1.9	9.4					
A8	3.8	7-89	7-89		1-14	4,881	21,038	47.7	188.9	15-71	439	1,384	0.0	0.0					
A9	3.3	12-89	12-89		1-9	1,047	3,478	0.9	7.5	10-65	37	159	0.0	0.0					
A10	3.9	2-90	7-90		1-7	2,786	13,698	0.0	0.0	8-59	374	645	0.0	0.0					
A11	3.0	2-90	2-90		1-16	4,675	14,586	0.0	0.0	17-64	150	337	0.0	0.0					
A12	4.0	10-90	10-90		1-18	2,945	8,836	0.0	0.0	19-56	655	1,505	0.0	0.0					
A13	3.0	1-91	1-91		1-32	3,740	14,343	0.0	0.0	33-53	281	486	0.0	0.0					
A14	2.8	4-91	4-91		1-11	2,777	6,582	0.0	0.0	12-38	281	449	0.0	0.0					
A15	2.8	5-92	5-92		1-12	5,573	11,809	0.0	0.0	13-37	299	561	0.0	0.0					
A16	4.5	1-93	1-93		1-22	4,675	17,756	0.0	0.0	23-29	206	393	0.0	0.0					
B1	3.6	5-93	8-93		1-10	3,273	12,155	177.7	822.8	11-17	393	1,403	2.8	15.0					
C1	2.4	4-93	5-93		1-12	6,358	20,570	130.9	523.6										
C2	2.4	7-93	8-93		1-10	3,553	7,480	289.9	514.3										
D1	4.0	12-90	2-91		1-23			11.2	24.3	24-47			0.9	3.7					
D2	2.4	12-92	1-93		1-24	4,208	11,688	0.9	14.0										
D3	2.8	12-92	1-93		1-13	3,179	8,228	0.0	0.0	14-24	187	309	0.0	0.9					
E1	3.8	9-92	12-92		3-23	3,890		1.9	22.4										
F1	1.3	7-94	10-94		1-9	6,330	12,052	0.0	0.0										
F2	1.0	7-94	8-94		1-11	9,967	21,729	4.7											
F3	1.0	7-94	8-94		1-11	11,248	31,313	11.2											

Notes:

[1] "Initial Period of Operation" represents period after waste placement has started and only a few lifts of waste and daily cover have been placed in the cell (i.e., no intermediate cover).

[2] "Active Period of Operation" represents period when waste thickness in cell is significant and/or an effective intermediate cover is placed on the waste.

[3] "Post Closure Period" represents period after final cover system has been placed on the entire cell.

[4] Flow rates are given in liter/hectare/day.

Figure 2 shows LCRS and LDS average daily flow rate data for a municipal solid waste management unit, located in Pennsylvania, that was active for 56 months. Subsequently, a final cover system containing a geomembrane was placed over the entire unit. Flow data for the 56-month operational period and a 25-month post closure period were obtained and analyzed. As Figure 2 shows, flow rates in both systems were highest immediately after the start of waste placement and thereafter decreased with time. During the first twelve months of operation, the average rate of flow into the LCRS sump decreased from 12,700 to 180 lphd. After that time, the LCRS flow rate stabilized and during the following 44 months, the rate of flow into the LCRS sump varied between 10 and 170 lphd. After final closure, the flow rate decreased even further, to between 10 and 80 lphd.

As illustrated in Figure 2, waste management unit development can be divided into three distinct periods. During the first period, herein referred to as the "initial period of operation", LCRS flow rates may be relatively high. High flows during this period are attributed to the occurrence of rainfall into a unit that initially contains little waste. To the extent rainfall occurs during this period, it will find its way rapidly into the LCRS. Obviously, the amount of LCRS flow during this period is highly dependent on climate. A lag exists between the time liquid first enters the LCRS and when it flows into the LCRS sump. The magnitude of the lag is largely dependent on the hydraulic characteristics (i.e., the length and slope of the LCRS and the hydraulic conductivity of the LCRS drainage material). Most available data indicate a decreasing LCRS flow rate with time during the initial period of operation. During the second period, referred to herein as the "active period of operation", the rate of flow into the LCRS continues to decreases and eventually stabilizes. This occurs as the amount of waste in the unit increases and as daily and intermediate layers of cover soil are placed. This trend in flow rates is also dependent on the type of waste but is likely representative of the trends observed at most new landfills, excluding those that accept sludges or other high moisture content wastes. During the "post closure period", the final cover system further reduces infiltration of rainwater into the waste, resulting in a further reduction in LCRS flow. Final covers containing geomembranes can, if functioning properly, virtually eliminate rainwater infiltration.

LDS flow rates for the waste management unit in Figure 2 were highest (860 lphd) at the beginning of operations and decreased in the following few months, becoming very low (i.e., less than 10 lphd) within approximately 15 months after the start of unit operation. The decrease in LDS flow with time is expected because: (i) flow rates in the LCRS during this time period decreased, and therefore, the potential for leakage through the top liner also decreased; (ii) most construction water initially present in the LDS flowed to the LDS sump in the first few weeks to months of unit operation; and (iii) the volume of compression and consolidation water for this waste management unit should be very small.

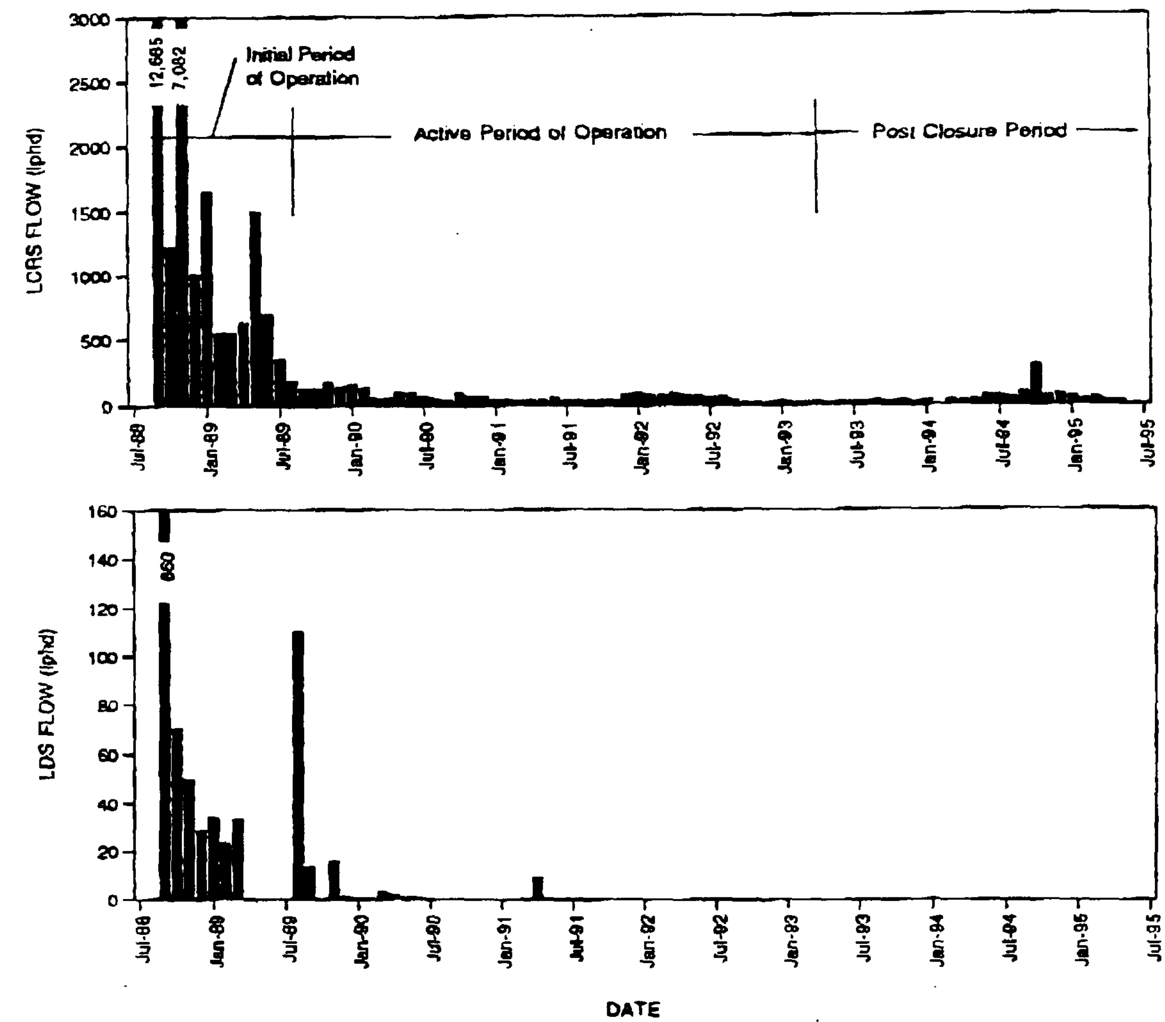

Figure 2. LCRS and LDS flow rates at a modern MSW landfill in Pennsylvania.

Table 2 summarizes LCRS and LDS flow data for the 26 waste management units containing GCLs in their composite top liners. Average and peak flow rates are reported for the three time periods described above. Table 2 shows that between the initial and active periods of operation, LCRS flow rates decreased one to two orders of magnitude and LDS flow rates decreased one to three orders of magnitude. Reported peak LCRS flow rates were up to 5 times the average, while peak LDS flow rates were up to 20 times the average. Table 3 presents the mean values of average and peak flows for the database.

Table 3. Mean values of flow for the data in Table 2 (Note: m = mean value; σ = standard deviation; values are in liter/hectare/day).

LCRS	Number of Units	Average Flow Rate		Peak Flow Rate	
		m	σ	m	σ
Initial Period of Operation	25	5,350	3,968	14,964	11,342
Active Period of Operation	18	276	165	752	590
Post-Closure Period	4	124	-	266	-

LDS	Number of Units	Average Flow Rate		Peak Flow Rate	
		m	σ	m	σ
Initial Period of Operation	26	36.6	68.5	141.8	259.9
Active Period of Operation	19	0.7	1.1	7.7	13.7
Post-Closure Period	4	0.2	-	2.3	-

Top Liner Hydraulic Efficiency

Table 4 summarizes calculated "apparent" efficiencies for the composite top liners of the 26 waste management units presented in Table 2. Liner apparent efficiency, AE, is calculated using the following equation:

$$AE\ (\%) = (1 - \text{LDS Flow Rate} / \text{LCRS Flow Rate}) \times 100 \qquad \text{(Equation 1)}$$

Table 4. "Apparent" efficiencies of composite liners containing GCLs[1].

Cells with Sand LDS				Cells with GT/GN LDS	
Cell No.	Initial Period of Operation (%)	Active Period of Operation (%)	Post-Closure Period (%)	Cell No.	Initial Period of Operation (%)
A1	100.00	100.00	100.00	D1	99.98
A2	99.90	99.33	100.00	D2	100.00
A3	98.97	98.71	99.55	E1	99.95
A4	96.01	98.75	100.00	F1	100.00
A5	97.23	97.50		F2	99.95
A6	98.58	100.00		F3	99.90
A7	99.37	99.20			
A8	99.02	100.00			
A9	99.91	100.00			
A10	100.00	100.00			
A11	100.00	100.00			
A12	100.00	100.00			
A13	100.00	100.00			
A14	100.00	100.00			
A15	100.00	100.00			
A16	100.00	100.00			
B1	94.57	99.29			
C1	97.94				
C2	91.84				
Number	19	17	4	Number	6
Range	91.84 - 100.00	97.5 - 100.00	99.55 - 100.00	Range	99.90 - 100.00
Mean	98.60	99.58	99.89	Mean	99.96
Median	99.90	100.00	100.00	Median	99.97

Notes: (1) Apparent Efficiency = (1 - LDS Flow / LCRS Flow) x 100 %

This liner efficiency is referred to as "apparent" because, as described above, flow into the LDS sump may be attributed to sources other than top liner leakage (Figure 1). If the only source of flow into the LDS sump is top liner leakage, then Equation 1 provides the "true" liner efficiency. Liner efficiency provides a measure of the effectiveness of a particular liner in limiting or preventing advective transport across the liner.

Table 4 presents calculated AE values for waste management units with sand LDSs (Landfills A, B, and C). For these units, the apparent efficiency is lowest during the initial period of operation (AE_m = 98.6 percent; where AE_m = mean apparent efficiency) and increases significantly thereafter (AE_m = 99.58 percent during the active period of operation and AE_m = 99.96 percent during the post closure period). The lower AE_m during the initial period of operation can be attributed to LDS flow from construction water. For units A, B, and C, calculated AE values during the active period of operation and the post-closure period may provide a reasonably accurate indication of true liner efficiency for the conditions at these units during the monitoring periods. It should be noted, however, that the true efficiency of a liner is not constant but rather a function of the hydraulic head in the LCRS and size of the area over which LCRS flow is occurring (the area is larger at high flow rates compared to low flow rates).

Table 4 also presents calculated AE values for waste management units with geonet LDSs (Landfills D, E, and F). The available data are limited to the initial period of unit operation. As shown in Table 4, AE_m for the six units with geonet LDSs is 99.96 percent. This value is much higher than the AE_m of liners of cells with sand LDSs for the same facility operational period (i.e., 98.60 percent). This higher efficiency can be attributed to the differences in liquid storage capacity and hydraulic transmissivity between sand and geonet drainage materials. A granular drainage layer can store a much larger volume of construction water and releases this water more slowly during the initial period of operation than does a geonet drainage layer. This suggests that, during the initial period of operation, the main source of flow in a sand LDS underlying a composite top liner containing a GCL is construction water.

Conclusions on Field Performance of Composite Liners Containing GCLs

From Table 2, LDS flows attributable to top liner leakage very from 0 to 50 lphd, with most values being less than about 2 lphd. These flow rates are very low. The data shown in Table 4 suggest that the true hydraulic efficiency of a composite liner incorporating a GCL may be greater than 99.90 percent. A liner with this efficiency, when appropriately used as part of an overall liner system, can provide a very high degree of liquid containment capability.

SHEAR STRENGTH OF HYDRATED GCLs

Overview

For a recent project, the authors were concerned with the long-term drained shear strength of hydrated GCLs at normal stresses in the range of 240 to 720 kPa. Drained shear strengths are applicable to long-term design and the range of considered normal stresses is applicable to conditions in a liner system at the base of a landfill. A testing program to evaluate the long-term drained shear strength of GCLs was undertaken and this program is ongoing. To develop interim values for preliminary design, the authors reviewed and analyzed available data from the technical literature on the consolidated-drained (CD) shear strength of GCLs. The findings of this review are presented below.

Required Deformation Rates to Achieve CD Conditions

To achieve consolidated drained (CD) test conditions, direct shear tests must be carried out at a very slow rate of shear displacement. The required displacement rate can be estimated using the well-known time-to-failure equation specified in American Society of Testing and Materials (ASTM) standard test method D 3080:

$$t_f = 50\ t_{50} \qquad \text{(Equation 2)}$$

where: t_f = total elapsed time to failure(s); and t_{50} = time required for the test specimen to achieve 50 percent primary consolidation under the specified normal stress, or increment(s) thereof. Using t_f from consolidation tests and an estimated failure displacement δ_t, the required shear displacement rate, d_r, can be calculated using the equation:

$$d_r = \delta_t\ /\ t_f \qquad \text{(Equation 3)}$$

Shan [1993] performed one-dimensional consolidation tests on the GCL products Claymax®, Gundseal®, Bentomat®, and Bentofix®. He evaluated t_f values for each product. The results of his evaluation are provided in Figure 3. With reference to this figure, at normal stresses in the range of 240 to 720 kPa, t_f values are in the range of about 100 to 400 hours. If it is assumed that a displacement of 25 mm is needed to achieve peak shear stress conditions, a required shear displacement rate of 0.05 to 0.25 mm/s is calculated. Only test results conducted at shear displacement rates that satisfy Equations 2 and 3 and the data from Shan [1993] should be considered to represent CD conditions. Test results at faster rates will yield lower shear strengths as a result of positive pore pressure development during the shearing phase of the test.

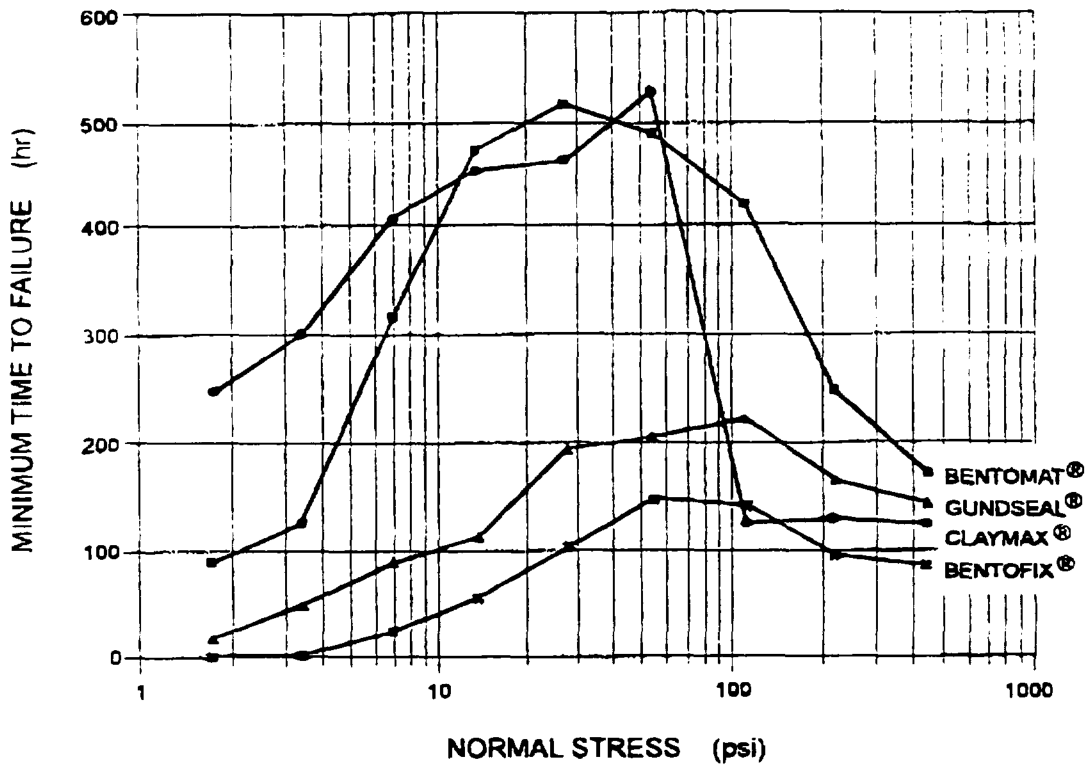

Figure 3. Relationship between time to failure of GCLs in direct shear tests and normal stress (from Shan, 1993; Note: 1 psi = 6.9 kPa).

It is noted that direct shear tests on GCLs are often performed in general accordance with the standard test method ASTM D 5321 ("*Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method*"). This method provides the following guidelines for selecting shear displacement rates for tests involving soils:

> "*11.6 Apply the shear force using a constant rate of displacement that is slow enough to dissipate soil pore pressures, as described in Method D 3080 (Note 9). If excess pore pressures are not anticipated, and in the absence of a material specification, apply the shear force at a rate of 1 mm/min (0.04 in./min).*"

The foregoing requirement calls for performing direct shear tests involving soils at a shear displacement rate in conformance with ASTM D 3080 if pore pressures are anticipated. For the soil component of GCLs (i.e., sodium montmorillonite), significant pore pressures will certainly be generated if the GCL is sheared at rates faster than those satisfying Equations 2 and 3. Interestingly, however, most test data available in the published literature were generated at the default shear displacement rate of 0.017 mm/s. Data generated at the default shear displacement rate are considered to reflect "undrained" or "partially-drained," and not "fully-drained," conditions.

Review of Available Information for Unreinforced GCLs

For purposes of shear strength characterization, two different categories of GCL can be considered: GCLs that do not contain internal reinforcement (hereafter referred to as unreinforced GCLs) and those that do (hereafter referred to as reinforced GCLs). Published information relevant to the CD shear strengths of unreinforced GCLs is very limited. The available information is summarized below.

- Daniel and Shan [1991] and Shan and Daniel [1991] reported CD direct shear test results for the GCL product Claymax®. Tests were performed using 60-mm diameter specimens and a shear deformation rate of 5 x 10^{-6} mm/s. Test results have been interpreted herein in terms of "peak (p)" and "large-displacement (ld)" normalized shear strengths. Peak displacements in these tests were 0.5 to 5 mm with the largest displacement corresponding to the lowest normal stress; the reported "ld" shear strengths correspond to shear displacements of approximately 6 to 9 mm. Results from the tests are as follows:

σ_n (kPa)	$(\tau/\sigma_n)_p$	ϕ_p	$(\tau/\sigma_n)_{ld}$	ϕ_{ld}
34	0.236	13.3°	0.236	13.3°
69	0.238	13.4°	0.209	11.8°
100	0.194	11.0°	0.165	9.4°
140	0.178	10.1°	0.137	7.8°

where: σ_n = normal stress on the shear plane at failure (kPa); τ = shear stress on the shear plane at failure (kPa); and ϕ = secant friction angle (dimensionless), calculated as the inverse tangent of τ/σ_n. It is noted that ϕ should also be interpreted as a measure of normalized shear strength and not as a "true" indication of internal friction. This data interpretation is illustrated in Figures 4 and 5.

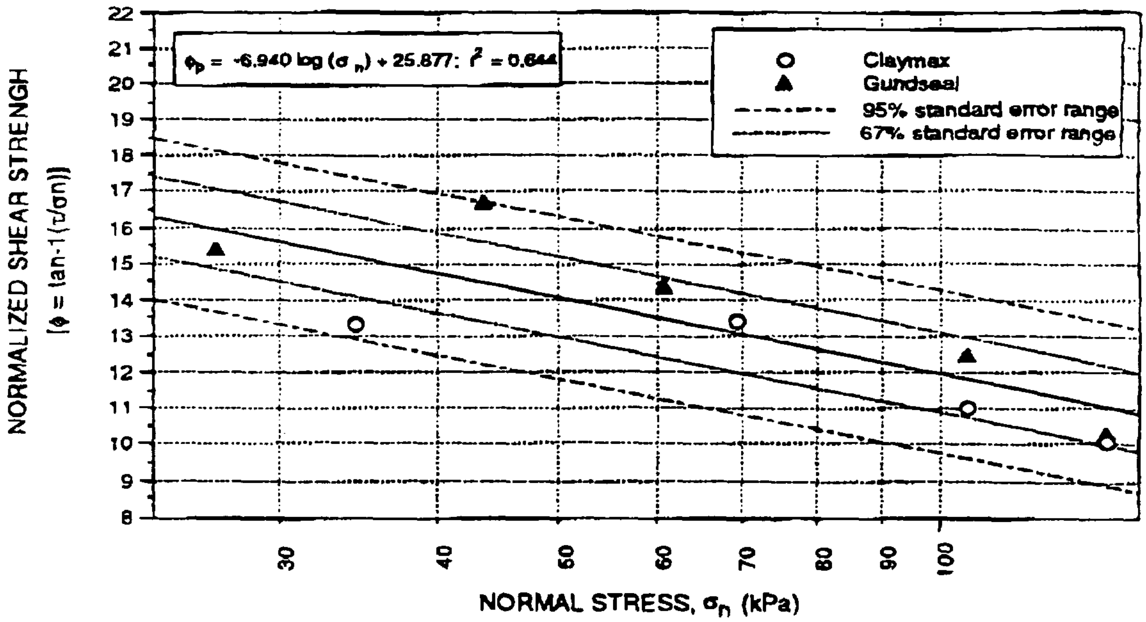

Figure 4. Log-linear regression analysis for peak CD conditions.

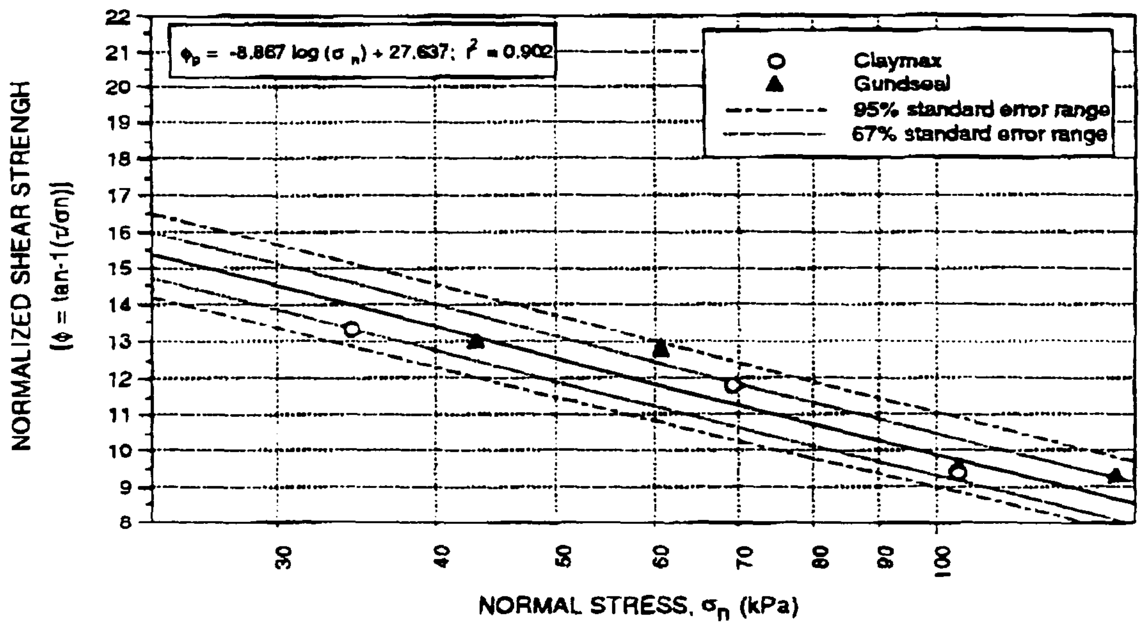

Figure 5. Log-linear regression analysis for large-displacement CD conditions.

- Daniel and Shan [1991], Daniel et al. [1993], and Shan [1993] reported direct shear CD test results for the GCL product Gundseal®. Tests were performed using 60-mm diameter specimens and a shear deformation rate of 5 x 10^{-6} mm/s. Test results have been interpreted herein in terms of peak and large-displacement normalized shear strengths. Typical peak displacements in these tests were 2 to 4 mm with the largest displacement corresponding to the lowest normal stress; the reported "ld" shear strengths correspond to shear displacements of approximately 9 to 12 mm. Results from the tests are as follows:

σ_n (kPa)	$(\tau/\sigma_n)_p$	ϕ_p	$(\tau/\sigma_n)_{ld}$	ϕ_{ld}
27	0.275	15.4°	-	-
44	0.300	16.7°	0.231	13.0°
61	0.256	14.4°	0.227	12.8°
100	0.223	12.6°	0.169	9.6°
140	0.181	10.3°	0.164	9.3°

The direct shear test results from Daniel and Shan are plotted in Figures 4 and 5 for "peak" and "large displacement" shearing conditions, respectively. Regression equations were developed to describe the test results. It is interesting to note the lesser amount of scatter in the results for the large-displacement shearing conditions compared to the peak shearing conditions.

The test results in Figures 4 and 5 only cover the stress range between 24 and 144 kPa. Even at these relatively low normal stresses, GCL CD shear strengths exhibit significant normal stress dependency. A basis is needed for extrapolating this stress dependency to higher normal stress. This basis was derived from published information from the soil mechanics literature on the shear strength of sodium montmorillonite. This information is summarized below.

- Mesri and Olson [1970] and Olson [1974] reported the results of constant rate-of-strain CD and consolidated-undrained (with pore pressure measurement) triaxial compression tests on homionic sodium montmorillonite consolidated from a slurry (Figure 6); approximate effective-stress normalized shear strengths and secant friction angles derived from the tests are as follows:

σ_n (kPa)	(τ/σ_n)	ϕ
72	0.21	12°
170	0.14	8°
340	0.10	6°
530	0.07	4°

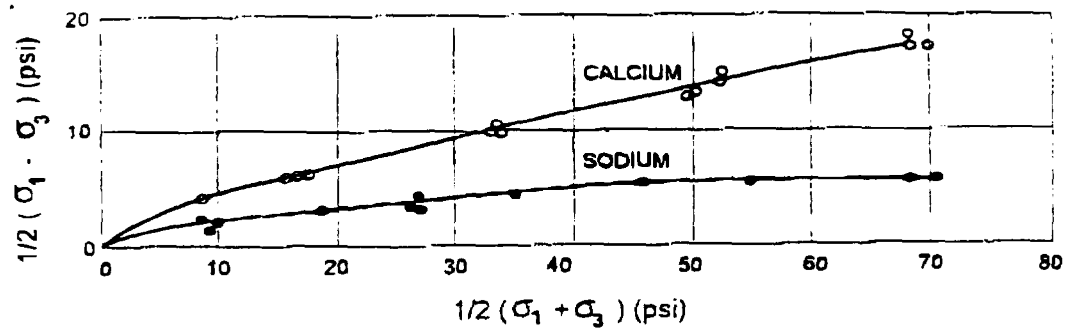

Figure 6. Effective-stress failure envelopes for calcium and sodium montmorillonite from CD and CU triaxial tests (from Mesri and Olson, 1970; Note: 1 psi = 6.9 kPa).

- Mitchell [1993] presented residual shear strength data for montmorillonite from Kenney [1967] and Chattopadhyay [1972]. Inspection of the residual shear strength data shown in Figure 7 reveals several significant points:
    - the residual friction angle exhibits significant stress dependency over a wide range of normal stress; stated differently the residual failure envelope is curved over a wide range of normal stress;
    - there may exist a normal stress above which the residual friction angle is independent of normal stress; based on Figure 7, this normal stress may be on the order of 480 kPa for sodium montmorillonite; and
    - the residual friction angle of montmorillonite is dependent on the dominant exchangeable cation and the soil pore chemistry; the smallest measured residual friction angle given in Figure 7 is 3° for homionic sodium montmorillonite in distilled water.

The GCL regression lines from Figures 4 and 5 are plotted along with the Mesri and Olson [1970] data in Figure 8. Reasonable agreement is observed between the Mesri and Olson data and the extrapolated regression lines for the unreinforced GCL. Also shown on this figure are the residual shear strengths for sodium montmorillonite developed by Kenney [1967] and Chattopadhyay [1972] as reported by Mitchell [1993]. These latter results further support the extrapolations presented in Figure 8.

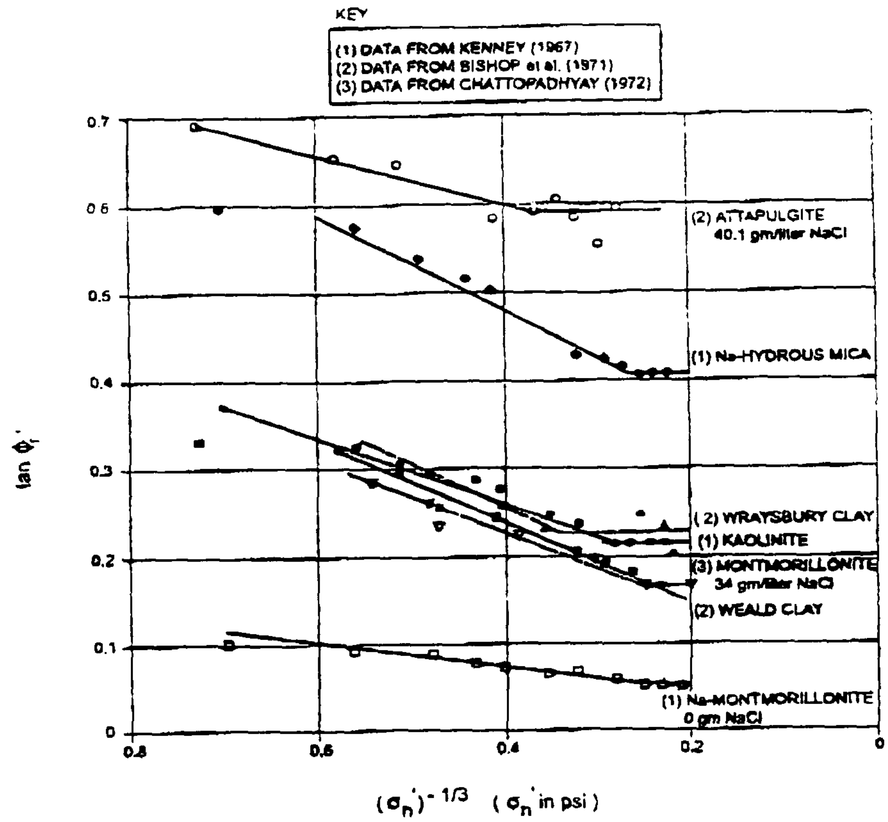

Figure 7. Residual effective-stress friction angles for clay minerals (from Mitchell, 1993; Note: 1 psi = 6.9 kPa).

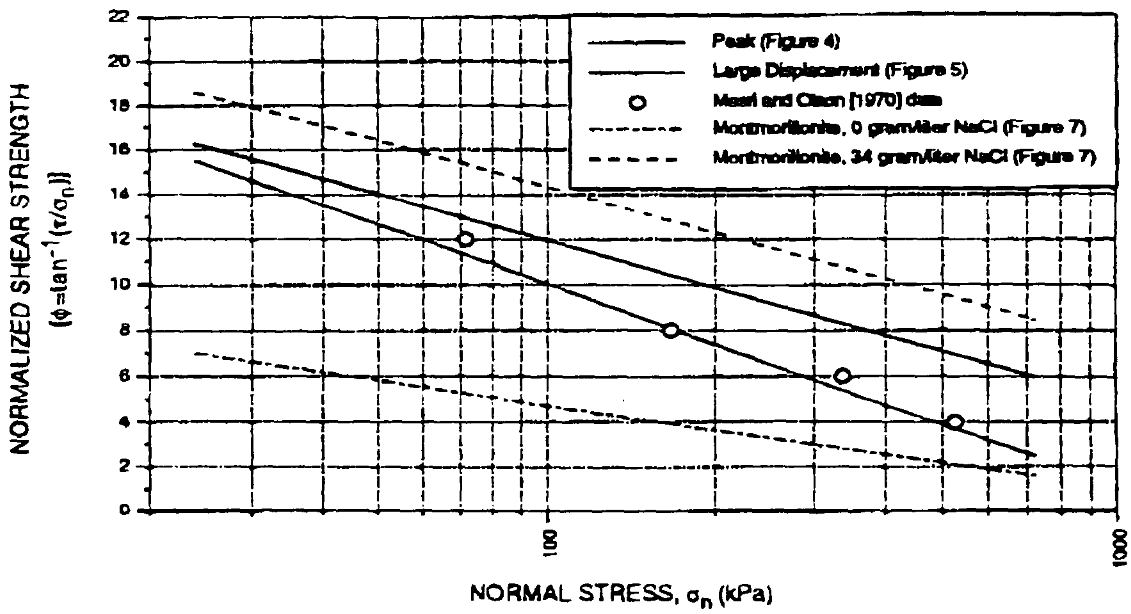

Figure 8. Comparison on montmorillonite shear strength data and GCL log-linear regression lines.

Review of Available Information for Reinforced GCLs

The authors were unable to find any information in the published technical literature on the CD shear strengths of reinforced GCLs at high normal stress. A few CD tests performed at low normal stress have been reported by Daniel and Shan [1991] for the product Bentomat®. These results cannot be extrapolated to higher normal stress, however, due to the current limited understanding of the effect of reinforcing fibers on the shear displacement-shear resistance-normal stress relationship for this type of material.

The authors have performed a limited number of consolidated-quick (CQ) direct shear tests on reinforced GCLs at normal stresses in the range of interest. Quick tests were performed at a displacement rate of 0.016 mm/s. While not "truly undrained" due to the lack of boundary drainage control in the direct shear test, the specimens in these tests will only undergo very limited pore pressure dissipation during the shear phase of the test due to the high rate of shear displacement. Due to these pore pressures, CQ tests at a given consolidation stress will result in lower GCL shear strengths than obtained from true CD tests at the same normal stress. CQ tests may therefore be considered to provide a lower bound of the CD shear strength of reinforced GCLs.

The results of the CQ direct shear tests on reinforced GCLs indicate relatively high peak shear strengths followed by a significant degree of shear softening (i.e., post peak decrease in shearing resistance). A typical test result is illustrated in Figure 9. Normalized peak and large displacement shear strengths, and the ratio of the two (ψ) for a normal stress of 480 kPa are given below:

	ϕ_p	ϕ_{ld}	τ_{ld}/τ_p
Bentomat®	29°	10°(↓)	0.32
Bentofix®	31°	16°(↓)	0.48
Claymax® 500SP	13°	6°(↓)	0.45

In the above table the downward arrow (↓) indicates that the GCL shearing resistance was decreasing at the end of the test (i.e., at a shear displacement of 40 to 50 mm). The ψ values reported above are low, generally in the range of 0.3 to 0.5. In contrast, ψ values for the CD direct shear tests on unreinforced GCLs were higher, typically in the range of 0.7 to 1.0. The ϕ_{ld} values reported above are somewhat larger than those obtained for the unreinforced GCLs. However, as noted above, observation of the shear force-displacement plots for the tests indicates that the shear stresses applied to the sample were decreasing at the ends of the tests, which typically occurred at a displacement of 40 to 50 mm. This observation, coupled with observations of the tested samples, that the GCL reinforcing fibers and stitching were still partially intact at the time the test was terminated, suggests that residual CD and CQ shear strengths of reinforced

GCLs may not be much larger than those of unreinforced GCLs. Clearly, testing is required to establish the large-displacement, high normal stress behavior of these materials, and to identify differences in product behavior based on differences in montmorillonite properties and reinforcing characteristics.

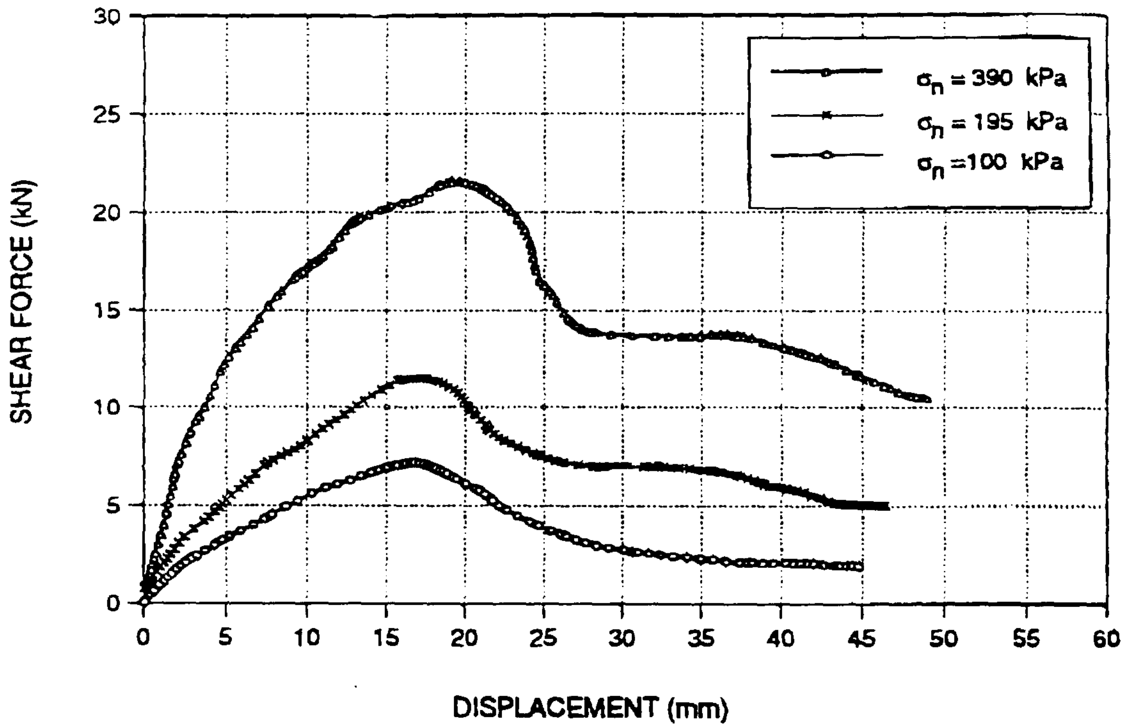

Figure 9. Results of CQ direct shear tests on reinforced Bentofix GCL.

Interim Design Values

Unreinforced GCLs: Based on the information presented in Figure 8, the authors used the following interim guidelines for performing liner system stability analyses for long-term drained conditions, for potential slip surfaces that involve internal shearing of unreinforced GCLs. These guidelines further assume that the GCL will hydrate through adsorption of water from an adjacent subgrade soil layer.

- Slope stability analyses are performed using: (i) peak internal GCL shear strengths and a minimum slope-stability factor of safety of 1.5; and (ii) large-displacement internal GCL shear strengths and a minimum slope-stability factor of safety of 1.15.

- Using the regression equation presented in Figure 4, peak normalized shear strengths are:

σ_n (kPa)	$(\tau/\sigma_n)_p$	ϕ_p
96	0.214	12.1°
240	0.157	8.9°
480	0.114	6.5°
720	0.106	6.1°

- Using the regression equation presented in Figure 5, large-displacement normalized shear strengths are:

σ_n (kPa)	$(\tau/\sigma_n)_{ld}$	ϕ_{ld}
96	0.178	10.1°
240	0.116	6.6°
480	0.070	4.0°
720	0.052	3.0°

For the large displacement strengths, a minimum friction angle cutoff of 3° was assumed based on the test results reported by Mitchell [1993], presented in Figure 7.

The normalized shear strengths given above are relatively low, and their use may be viewed by some as overconservative. This view should be tempered with the realization that the large-displacement GCL shear strengths reported in the technical literature do not represent true residual minimums (due to the limited displacement of the direct shear apparatus) and no allowance has been made for the possible effects of drained creep of the GCL under working stress conditions. Furthermore, the available CD direct shear test results for unreinforced GCLs correlate well with the triaxial compression test results for sodium montmorillonite from Mesri and Olson [1970] and Olson [1974] (Figure 6). Finally, it is noted that the foregoing approach, which utilizes a smaller slope stability factor of safety with the large displacement shear strengths than the factor of safety used with the peak shear strengths, is similar to the approaches advocated by Byrne [1994] and Stark and Poeppel [1994].

Reinforced GCLs: Recognizing the lack of data on the CD strength of reinforced GCLs at high normal stress, the complex behavior and high degree of shear-softening exhibited by these products, the authors utilized the same factors of safety and GCL long-term shear strengths for reinforced GCLs as for unreinforced GCLs. It is recognized that this assumption is conservative. However, given the limitations with respect to the available reinforced GCL test data (e.g., the technical literature does not contain any "true" CD direct shear test results for reinforced GCLs at high normal stress) and the other factors discussed above, the authors believe the assumption was prudent.

SHEAR STRENGTH OF GCL-GEOMEMBRANE INTERFACES

Direct Shear Testing Program

For a project located in the desert of southeastern California, the authors performed 14 interface direct shear tests on unhydrated GCL-textured HDPE geomembrane interfaces. The tests were performed in a 300 mm x 300 mm shear box following procedures in general accordance with ASTM D 5321. Three different GCLs were tested. The geomembrane used in the tests was from a single roll of material and samples were selected based on visual observation of a consistent degree of texturing. The tests were carried out in a manner that allowed shearing either at the GCL interface or internally within the GCL bentonite layer. Tests were carried out at normal stresses ranging between approximately 350 and 1,920 kPa. Sliding in the tests consistently occurred at the interface and not within the GCL. Thus, the test results correlate to interface failures and at the same time provide conservative lower bound unhydrated shear strengths for the tested GCLs under the project testing conditions.

Typical test results are presented in Figure 10 and summarized in Table 5. The tests correspond to two shearing rates, namely 0.016 mm/s and 0.0007 mm/s. Interface friction angles obtained from the tests at the slower shearing rate are 1° to 2° lower than interface friction angles obtained from tests at the higher shearing rate. The test results also reveal an interface shear strength stress-dependency with secant interface friction angles 5° to 10° lower at 1,920 kPa than at 350 kPa. The interfaces exhibited only minor amounts of shear softening (typically less than 1 to 2°) at test displacements of up to about 50 mm.

Comment on Results

The foregoing interface direct shear test results illustrate the ranges of shear strengths obtained and several of the factors that affect this strength including normal stress, displacement rate, and magnitude of displacement.

The authors note that they have observed relatively wide variances in the degree of texturing of geomembranes, even from a given manufacturer. The degree of texturing significantly influences the interface shear strength. Thus, the strength values reported above should not be considered appropriate for design. Interface shear strengths for design should be established on a project-specific basis and construction-phase quality control testing should be used to establish that materials delivered to the construction site can achieve the interface strengths established during design.

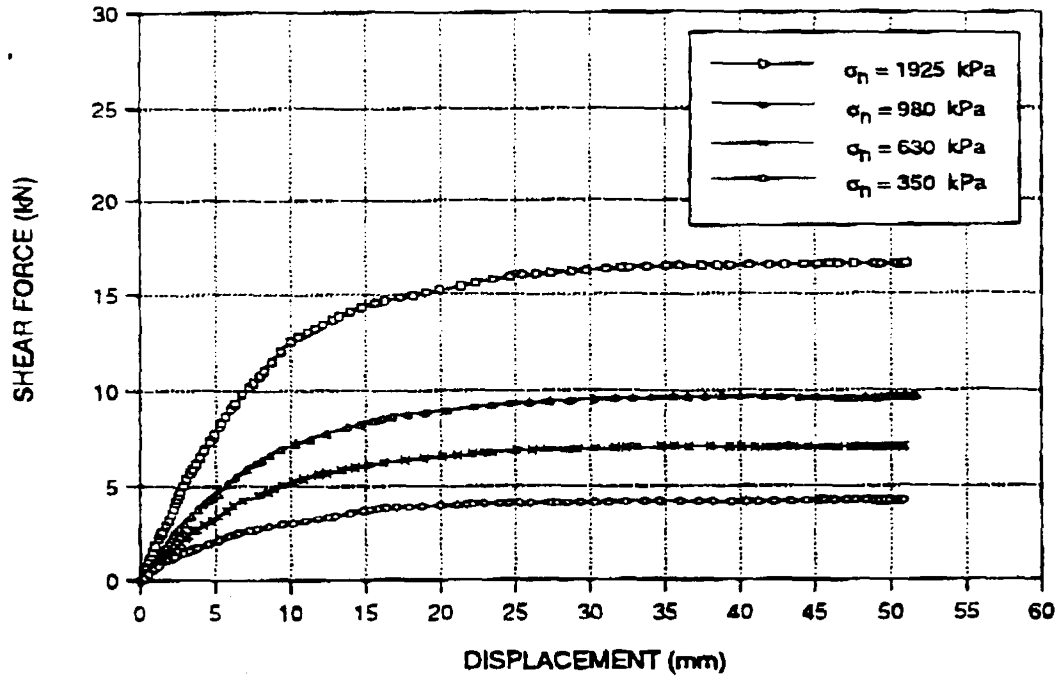

Figure 10. Results of direct shear tests on unhydrated Bentofix GCL-textured HDPE geomembrane interface.

HYDRATION OF GCLs ADJACENT TO SOIL LAYERS

Overview of Testing Program

The authors conducted an extensive laboratory testing program to evaluate the potential for hydration of GCLs placed against a compacted subgrade soil layer. Hydration tests were performed on three different GCL products to evaluate the effects of: (i) test duration (i.e., hydration time); (ii) soil initial water content; (iii) thickness of soil layer; and (iv) overburden pressure. Three commercially-available GCL products, namely, Claymax®, Bentomat®, and Bentofix® were used in the testing program. The soil used in the testing program was obtained from the USEPA GCL Field Test Site at the ELDA-RDF facility in Cincinnati, Ohio. This material is classified as low plasticity clay (CL) based on the Unified Soil Classification System (USCS). Tests were performed on two different soil samples and consistent results were obtained between samples. The results reported herein were obtained from tests on a sample with 99 percent of the soil passing the U.S. No. 200 standard sieve and 33 percent smaller than 2 μm (clay fraction). The liquid limit of the soil is 41 and the plasticity index is 19. The soil has an optimum moisture content (OMC) of 20 percent and a maximum dry unit weight of 16.7 kN/m^3 based on the standard Proctor compaction method (ASTM D 698).

Table 5. Direct shear test results of textured 80-mil HDPE geomembrane/unhydrated GCL interfaces[1].

Test Number	Type of GCL	Normal Stress (kPa)	Displacement Rate (mm/s)	Large Displacement Secant Friction Angle[2] (ϕ_{ld}°)
1	Bentomat GCL (nonwoven side)	350	0.016	24°
2	Bentomat GCL (nonwoven side)	620	0.016	24°
3	Bentomat GCL (nonwoven side)	960	0.016	23°
4	Bentomat GCL (nonwoven side)	960	0.0007	22°
5	Bentomat GCL (nonwoven side)	1,920	0.016	19°
6	Bentomat GCL (nonwoven side)	1,920	0.0007	17°
7	Bentofix GCL (nonwoven side)	350	0.016	28°
8	Bentofix GCL (nonwoven side)	620	0.016	26°
9	Bentofix GCL (nonwoven side)	960	0.016	23°
10	Bentofix GCL (nonwoven side)	1,920	0.016	21°
11	Gundseal GCL (bentonite granules side)	350	0.016	34°
12	Gundseal GCL (bentonite granules side)	620	0.016	29°
13	Gundseal GCL (bentonite granules side)	960	0.016	27°
14	Gundseal GCL (bentonite granules side)	1,920	0.016	24°

Notes:
(1) The tests were performed using unhydrated GCLs and in a manner that allowed shearing at the geomembrane/GCL interface, as well as within the GCL bentonite layer.
(2) Final displacements in the tests were in the range of 25 to 50 mm.

Testing Apparatus and Procedure

Figure 11 shows the apparatus specially designed to conduct the GCL hydration tests. The apparatus consists of a polypropylene mold 75 mm in diameter and 150 mm in height. A geomembrane/GCL/soil composite specimen is placed in the mold and covered with two layers of a thin vapor barrier. A loading platen is placed on the specimen for application of overburden pressure.

To process the soil, it was first passed through a U.S. No. 4 standard sieve. The soil was then moisture conditioned to achieve the desired moisture content. The moist soil was placed in the mold in a loose condition and statically compressed to 50-mm thick lifts. The soil was compacted to a dry unit weight equal to approximately 90 percent of the maximum dry unit weight based on the standard Proctor method (ASTM D 698). Two soil lifts were used giving a total thickness of 100 mm. The GCL and geomembrane specimens were carefully trimmed from the same sheets. The initial moisture content of the GCL was measured by taking a small sample from the same GCL sheet and measuring its weight before and after oven drying. The initial moisture content of the GCLs varied between 15 and 20 percent.

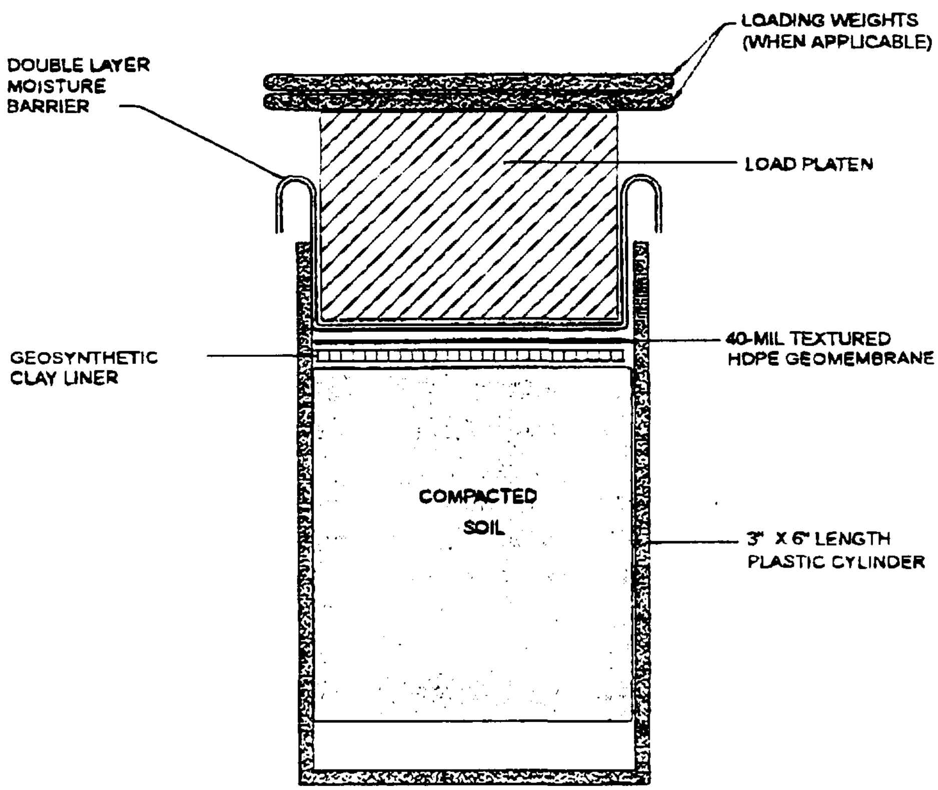

Figure 11. Simplified diagram of GCL hydration test set-up.

The GCL and geomembrane were placed on the soil and covered with the vapor barrier. The side of the GCL placed against the soil was woven in the case of Claymax® and nonwoven for Bentomat® and Bentofix®. Overburden pressure of 10 kPa was applied on the composite specimen utilizing standard weights which were placed on the loading platen. The entire apparatus was then placed in a temperature and humidity controlled room for the desired hydration time period. At the end of the hydration period, the test specimen was removed and the water content of the GCL and soil were measured. The final moisture content of the GCL was measured by weighing the entire GCL specimen before and after oven drying. The final moisture content of the soil was measured as the average water content of three samples obtained from the top, middle, and bottom of the soil specimen.

Testing Conditions and Results

As previously described, test conditions were varied to evaluate the effects of several factors on the hydration of GCLs. To evaluate the effect of test duration, tests were performed where the GCL was in contact with the soil for 5, 25, and 75 days. Soil specimens were compacted to initial moisture contents equal to OMC, 4 percentage points dry of OMC, and 4 percentage points wet of OMC to evaluate the effect of soil initial moisture content on GCL hydration.

Figures 12, 13, and 14 present the results of the hydration tests for the GCL products Claymax®, Bentomat®, and Bentofix®, respectively. These figures show that the moisture content of all three GCLs increased significantly as a result of contact with compacted subgrade soil. The increase in GCL water content was significant after only five days of hydration. With increasing time, GCL water content continued to increase at a decreasing rate. For most tests, GCL water content reached a maximum value after about 25 days of soil contact and for some of the tests water content continued to increase even after 75 days of hydration. It is interesting to note that all three GCL products showed relatively similar behavior. Increases in water content were comparable for the three GCL products despite differences in GCL fabric (i.e., woven vs. nonwoven) and types of bentonite clay used to manufacture the GCLs.

Figures 12, 13, and 14 illustrate the influence of soil subgrade initial moisture content on the hydration of GCLs. From these figures, it is evident that the moisture content of the GCL for any particular hydration time increases as the initial moisture content of the soil increases. These figures also show that a small increase in soil initial moisture content can have a significant impact on GCL moisture content. For example, after 75 days of hydration, the moisture content of Claymax® was approximately 16 percent higher when the initial moisture content of the soil was equal to OMC than when it was 4 percentage points drier than OMC. This behavior is expected because more water is available in the soil for the GCL to hydrate.

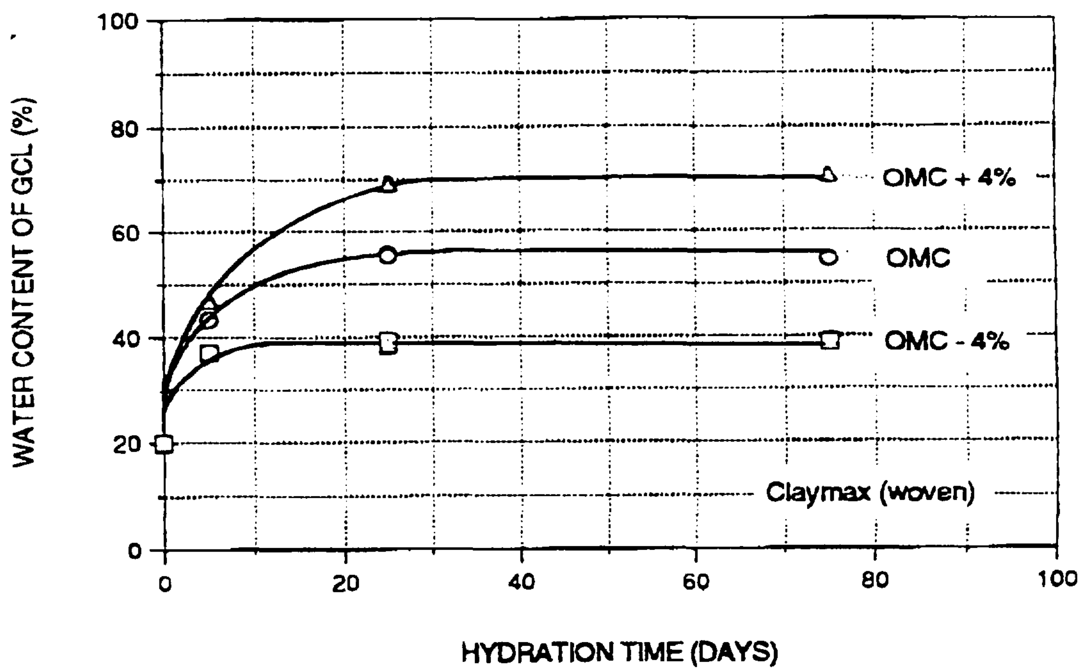

Figure 12. Increase in GCL moisture content due to contact with compacted subgrade soil: Claymax® with woven geotextile against soil.

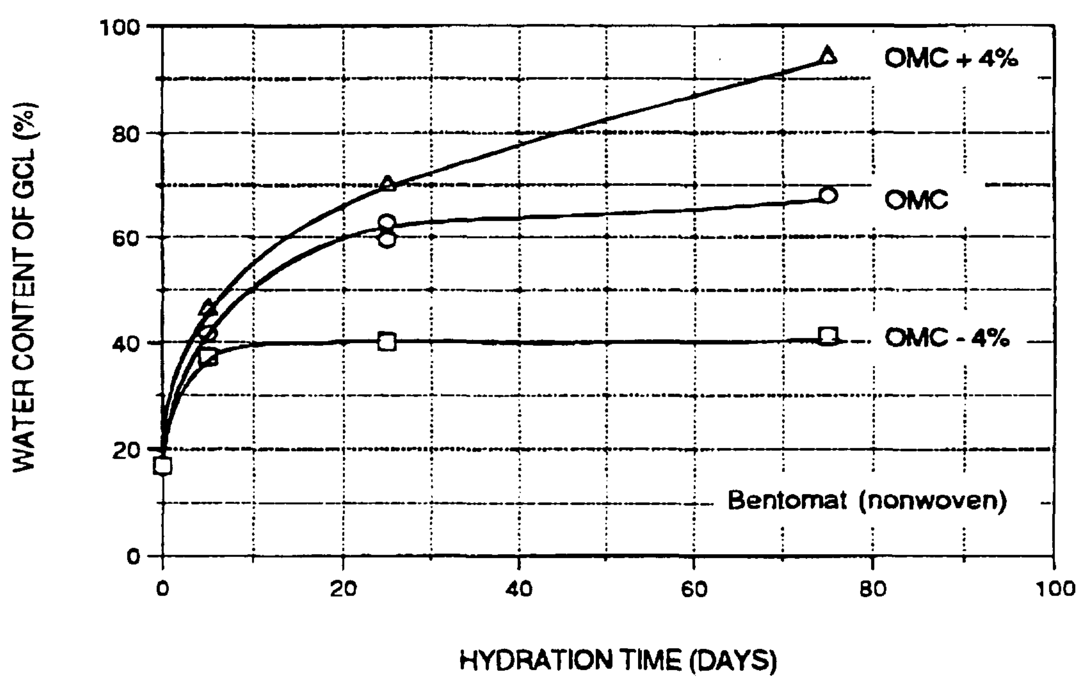

Figure 13. Increase in GCL moisture content due to contact with compacted subgrade soil: Bentomat® with nonwoven geotextile against soil.

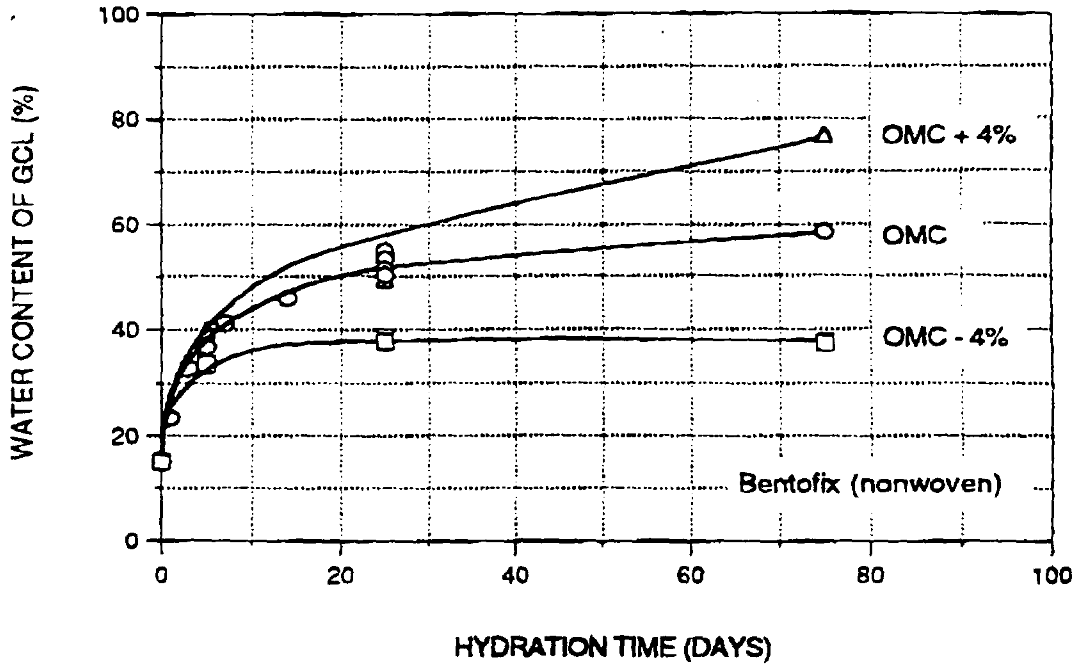

Figure 14. Increase in GCL moisture content due to contact with compacted subgrade soil: Bentofix® with nonwoven geotextile against soil.

The examination of the curves shown in Figures 12, 13, and 14 shows that the time required for the GCL to reach its final moisture content is less in the case of a dry soil than in the case of a wet soil. At the lowest soil initial moisture content tested, GCL moisture content ceased to increase after about 5 to 25 days. At the highest initial moisture content tested, the Bentomat® and Bentofix® GCLs continued to increase in moisture content after 75 days of hydration.

To evaluate the effect of soil layer thickness, specimens were prepared using 50, 100, 150, and 200 mm of soil thickness. Soil initial moisture content was 20 percent and dry unit weight was 14.9 kN/m^3 for all specimens. Figure 15 shows the results of hydration tests for the Bentofix® GCL after 25 days of hydration. The GCL moisture content increased with the increase of the soil layer thickness. However, it appears that only a small change in moisture content increase occurs for thicknesses greater than 100 mm.

The effect of overburden pressure on GCL hydration is illustrated in Figure 16 for the Bentofix® GCL. As shown in this figure, overburden pressure in the range of 5 to 390 kPa did not significantly affect the rate of GCL hydration during the 25-day test duration.

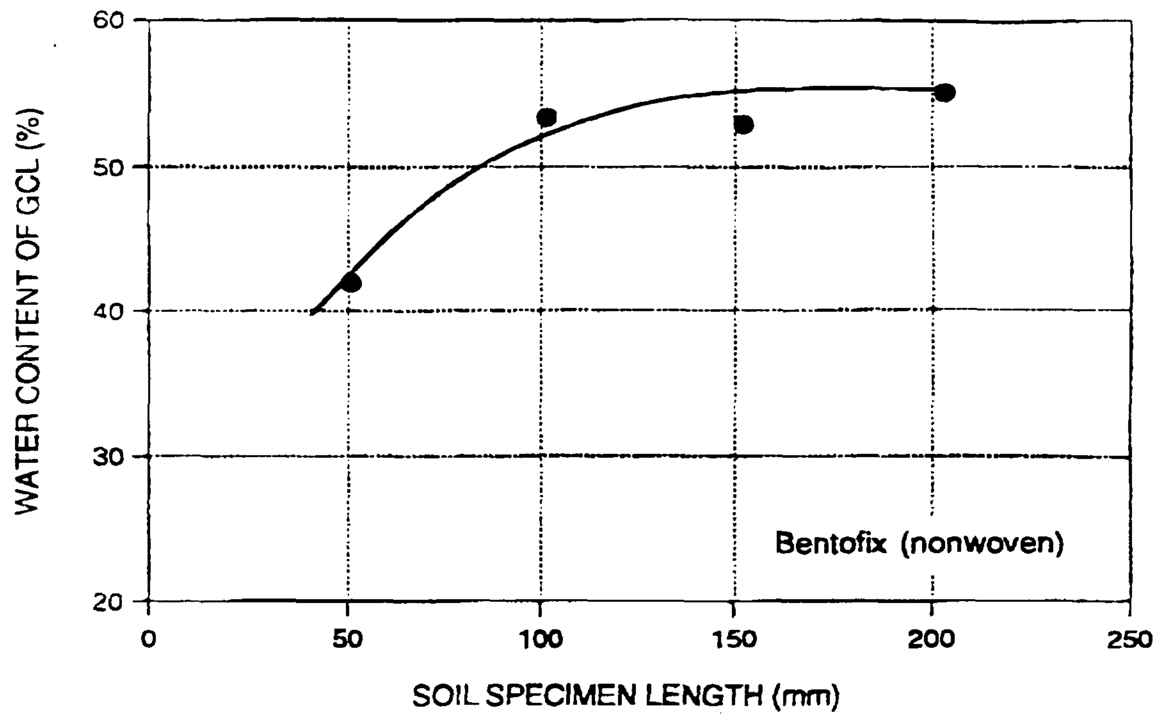

Figure 15. Influence of subgrade soil layer thickness on GCL moisture content.

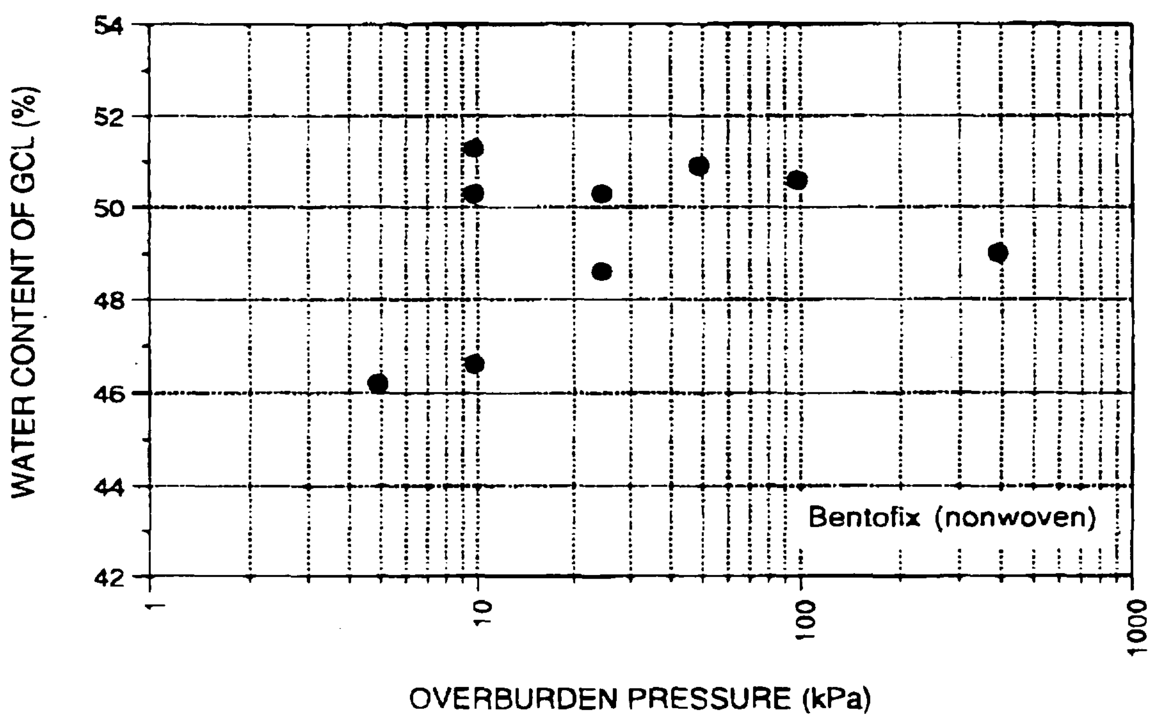

Figure 16. Influence of overburden pressure on the increase in GCL moisture content.

Summary

From the testing program results described above, the following can be concluded:

- GCLs will hydrate when placed in contact with subgrade soils compacted within the range of moisture contents typically found in earthwork construction specifications; this conclusion is consistent with data provided by Daniel et al. [1993]; even for the driest soil (compacted 4 percentage points dry of OMC), GCL moisture contents consistently increased from an initial value in the range of 15 to 20 percent up to about 40 percent within a 100-day period; it should thus be anticipated that GCLs placed even against relatively dry compacted subgrades will undergo substantial hydration;

- given that Daniel et al. [1993] have shown that long-term GCL shear strengths are insensitive to water content for water contents above about 50 percent, stability analyses involving GCLs placed in contact with compacted subgrade soils should be based on hydrated GCL shear strengths;

- significant increases in GCL moisture contents may occur within a few days of GCL contact with a moist soil; the rate of GCL hydration is initially highest and then decreases with increasing time;

- within the range of conditions tested a higher soil moisture content results in a higher GCL moisture content;

- larger soil layer thickness results in a larger increase in GCL moisture content, however, for soil layer thicknesses greater than 100 mm only insignificant increases were observed with increasing soil layer thickness;

- overburden pressure within the range tested (i.e., 5 to 390 kPa) did not influence the hydration process; and

- differences between GCL products tested (i.e., type of bentonite clay and fabric) did not seem to significantly affect the test results.

FAILURE OF LANDFILL COVER SYSTEM CONTAINING A GCL

Description of Cover System

The authors recently investigated the failure of a cover system for a municipal solid waste landfill near Atlanta, Georgia. The failure is described in more detail by Vander Linde et al. [1995]. The cover system was constructed in the fall of 1994 on 3H:1V (horizontal:vertical) side slopes to a maximum height above surrounding ground of approximately 18 m. The cover system consisted of, from top to bottom:

- 300-mm thick layer of final cover soil which is classified as silty sand containing approximately 40 percent fines based on ASTM D 2487, and which has a hydraulic conductivity in the range of 10^{-4} to 10^{-3} cm/s;

- stitch-bonded reinforced GCL; and

- 150- to 300-mm thick layer of intermediate cover soil which served as a foundation for the overlying final cover components.

Failure of System

During the winter of 1995, the cover system experienced several episodes of downslope movement. The first major episode occurred approximately one month after the completion of construction; the movement occurred after a three-day period in which 58 mm of rain fell at the site. The next major episode occurred six weeks later, after two days of inclement weather generated about 41 mm of rainfall at the site. Total downslope movements exceeded 1 m at some locations. The observed failure mechanism was sliding of the final cover soil on top of the GCL.

Analysis of Failure

The episodes of downslope movement both followed periods of extended rainfall at the site. A slope stability back-analysis of the cover system was performed which accounted for the influence of rainfall-induced seepage forces on cover system factor of safety against downslope sliding. The back-analysis involved two steps:

- estimating seepage forces within the cover soil using several different calculation methods and parameter values; and

- calculating the resulting slope stability factors of safety for the range of estimated seepage forces.

The evaluation of seepage forces involved calculating the water build-up (i.e., hydraulic head) within the final cover soil on top of the GCL. Head was calculated using a methodology developed by Giroud and Houlihan [1995] and checked using the United States Environmental Protection Agency (USEPA) Hydrologic Evaluation of Landfill Performance (HELP) computer program Version 3.03 [USEPA, 1994a, 1994b]. The values of head calculated using these approaches ranged from 150 mm to the full thickness of the cover soil layer, 300 mm.

Calculations to obtain slope stability factors of safety were performed using the equations presented by Giroud et al. [1995a, 1995b]. An important input to the equations is the shear strength of the interface between the cover soil and GCL. Tests to evaluate the shear strength of this interface had not been carried out as part of the original design. For the back-analysis of the failure, a range of friction angles (20° to 26°) was considered for the cover soil-GCL interface; this range likely brackets the actual interface strength and includes the value of 24° originally assumed by the design engineer. Calculations were performed and the following results were obtained:

Interface Friction	Factor of Safety (FS) vs. Hydraulic Head		
Angle (degrees)	0 mm	100 mm	200 mm
20°	1.09	0.84	0.60
24°	1.35	1.04	0.73
26°	1.47	1.13	0.80

These calculation results demonstrate the significant impact of seepage forces on the stability of the final cover soil. Even with the largest assumed interface strength, only 140 mm of head buildup is required to decrease the slope stability factor of safety to less than 1.0. Interface shear strength tests performed after the completion of the back analyses resulted in peak and large-displacement secant friction angles for the GCL-cover soil interface, at the applicable normal stress, of 23° and 21°, respectively.

Summary

The primary factor contributing to the observed final cover soil movements was the build-up of seepage forces in the final cover soil during periods of heavy rain. Seepage forces were not accounted for in the design. If seepage forces had been accounted for, the potential for instability likely would have been identified during preparation of the design. The development of seepage forces in cover soils is typically minimized by the inclusion of a drainage layer above the low-permeability barrier component of the cover (in this case, the GCL). A secondary factor contributing to the movements was a final cover soil-GCL interface shear strength lower than assumed in the design. An interface friction angle of 24° was assumed by the design engineer, based on information provided by the GCL manufacturer. The actual project-specific interface shear strength was closer to 21°. This result highlights the fact that actual interface strengths can only be assessed by project-specific testing; such testing was not performed for the project.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Robert R. Landreth and Mr. David A. Carson of the U.S. Environmental Protection Agency, Risk Reduction Research Laboratory for their support in the evaluation of double-liner system performance.

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APPENDIX J

MATERIAL COMPATIBILITY STUDY

PROJECT SPECIFIC
SYNTHETIC LEACHATE

PROJECT SPECIFIC SYNTHETIC LEACHATE GENERATION

Soil and geosynthetic materials tested for chemical compatibility purposes during this testing program were exposed to a project specific synthetic leachate hereon referred to as synthetic leachate. The synthetic leachate was derived as follows:

- A bulk composite sample consisting of the grab sediment samples CSB-S1, CSB-S2, CSB-S3, CSB-S4, CSB-S5, CSB-S6, CSB-S7, CSB-S8, CSB-S9 and CSB-S10, recovered from the project site by O'Brien and Gere Engineers, Inc. in 5-gallon buckets, was formed by mixing equal portions by wet weight.

- The bulk composite sample was then used to generate the synthetic leachate in accordance with EPA Toxicity Characteristic Leaching Procedure (TCLP) extraction procedure, utilizing the standard solution No. 1 (pH=4.93).

- The extraction was conducted in 2-liter volumes and a total volume of approximately 80 liters of extract was generated in 40 batches.

- All of the extracted liquid was then transferred into a large container creating a composite extracted liquid, which was then used in the testing program as the synthetic leachate.

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Web Site: www.interactionspecialists.com

GEOSYNTEC CONSULTANTS

January 2, 2001

Mr. Gary M. Wantland, P.E.
URS Greiner Woodward-Clyde
7650 West Courtney Campbell Causeway
Tampa, Florida 33607

Subject: Laboratory Test Results Transmittal
Permeability and Compatibility Testing
Samples: Soil and Geosynthetic Clay Liner (GCL)

Dear Mr. Wantland;

GeoSyntec Consultants (GeoSyntec) is pleased to present the attached test results for the above-mentioned project. The note section below addresses sample preparation, sample disposal and a disclosure statement.

GeoSyntec appreciates the opportunity to provide laboratory testing services for this project. Should you have any questions regarding the attached document(s), or if you require additional information, please do not hesitate to contact either of the undersigned.

Sincerely,

Cuneyt Gokmen
Program Manager

Robert H. Swan, Jr.
Laboratory Manager

Attachment

Notes:
(1) Unless otherwise noted in the test results the sample(s)/specimen(s) were prepared in accordance with the applicable test standards or generally accepted sampling procedures.
(2) Contaminated/chemical samples and all related laboratory generated waste (i.e., test liquids, PPE, absorbents, etc.) will be returned to the client or designated representative(s), at the client's cost, within 60 days following the completion of the testing program, unless special arrangements for proper disposal are made with GeoSyntec.
(3) Materials that are not contaminated will be discarded after test specimens and archived specimens are obtained. Archived specimens will be discarded 60 days after the samples are received at the laboratory, unless long-term storage arrangements are specifically made with the laboratory.
(4) The reported results apply only to the materials and test conditions used in the laboratory testing program. The results do not necessarily apply to other materials or test conditions. The test results should not be used in engineering analysis unless the test conditions model the anticipated field conditions. The testing was performed in accordance with general engineering testing standards and requirements. The reported results are submitted for the exclusive use of the client to whom it is addressed.

GLI1096/SGI00199.TESTCOVLTR.DOC

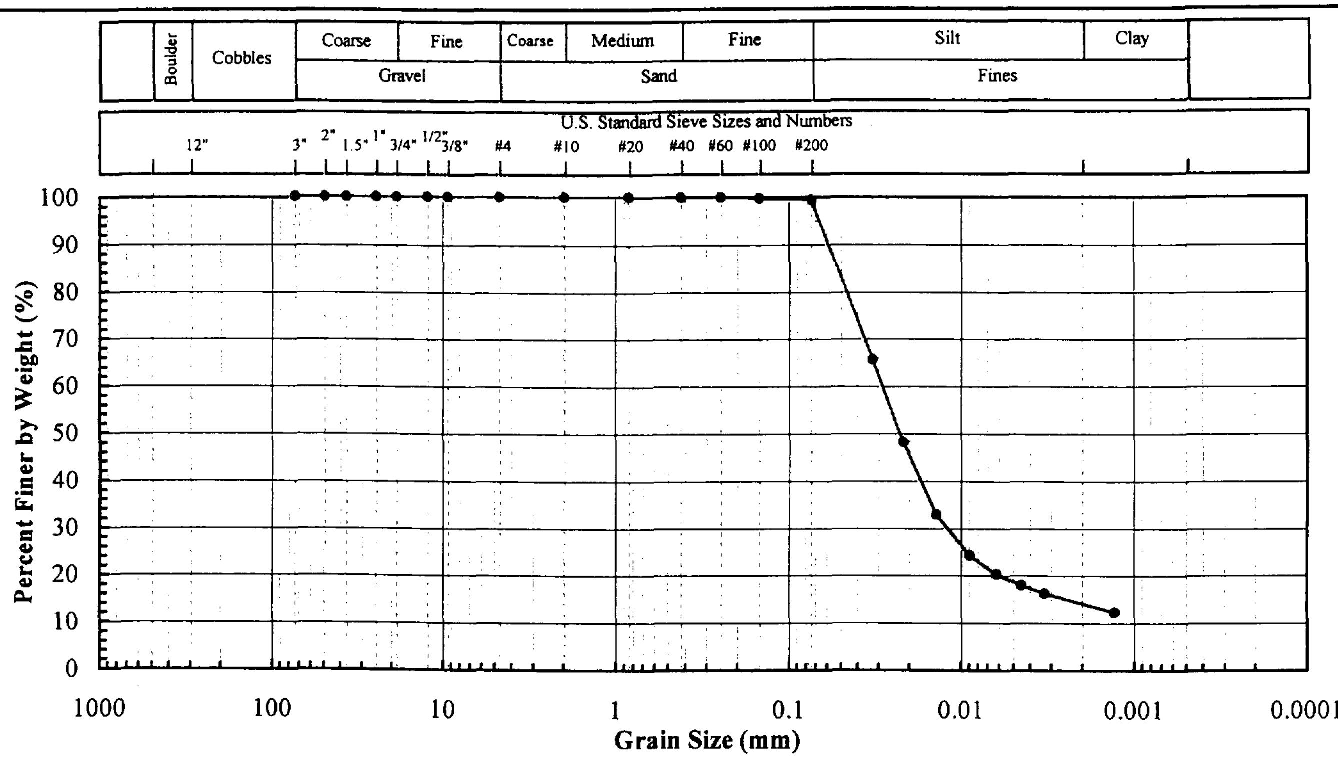
GEOSYNTEC CONSULTANTS
Soil-Geosynthetic Interaction Testing Laboratory
5775 Peachtree Dunwoody Road, Suite 11D, Atlanta, Georgia 30342
Ph: (404) 705 9500 Fax: (404) 705 9300

Project Name:	Sauget Area 1 TSCA LF
Project No:	GLI1096
Client Sample ID:	Clay Liner Soil No. 1
Lab Sample No:	AL7852

ASTM D 2216, D 1140, D 422, C 136, D 4318, D 2487

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification

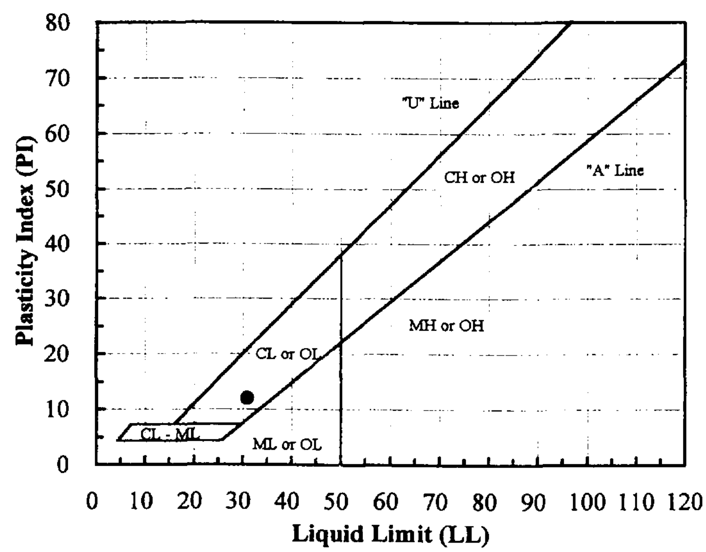


Sieve No.	Size (mm)	% Finer
3"	75	100
2"	50	100
1.5"	37.5	100
1"	25	100
3/4"	19	100
1/2"	12.5	100
3/8"	9.5	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	100
#60	0.250	100
#100	0.150	100
#200	0.075	99

Hydrometer Particle Diameter (mm)	% Finer
0.050	83
0.020	46
0.005	18
0.002	14
0.001	

Gravel (%):	
Sand (%):	0.8
Fines (%):	99.2
Silt (%):	85.3
Clay (%):	13.9

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (%)	PL (%)	PI (-)	Engineering Classification
Clay Liner Soil No. 1	AL7852	14.9	99.2	31	19	12	CL - Lean Clay

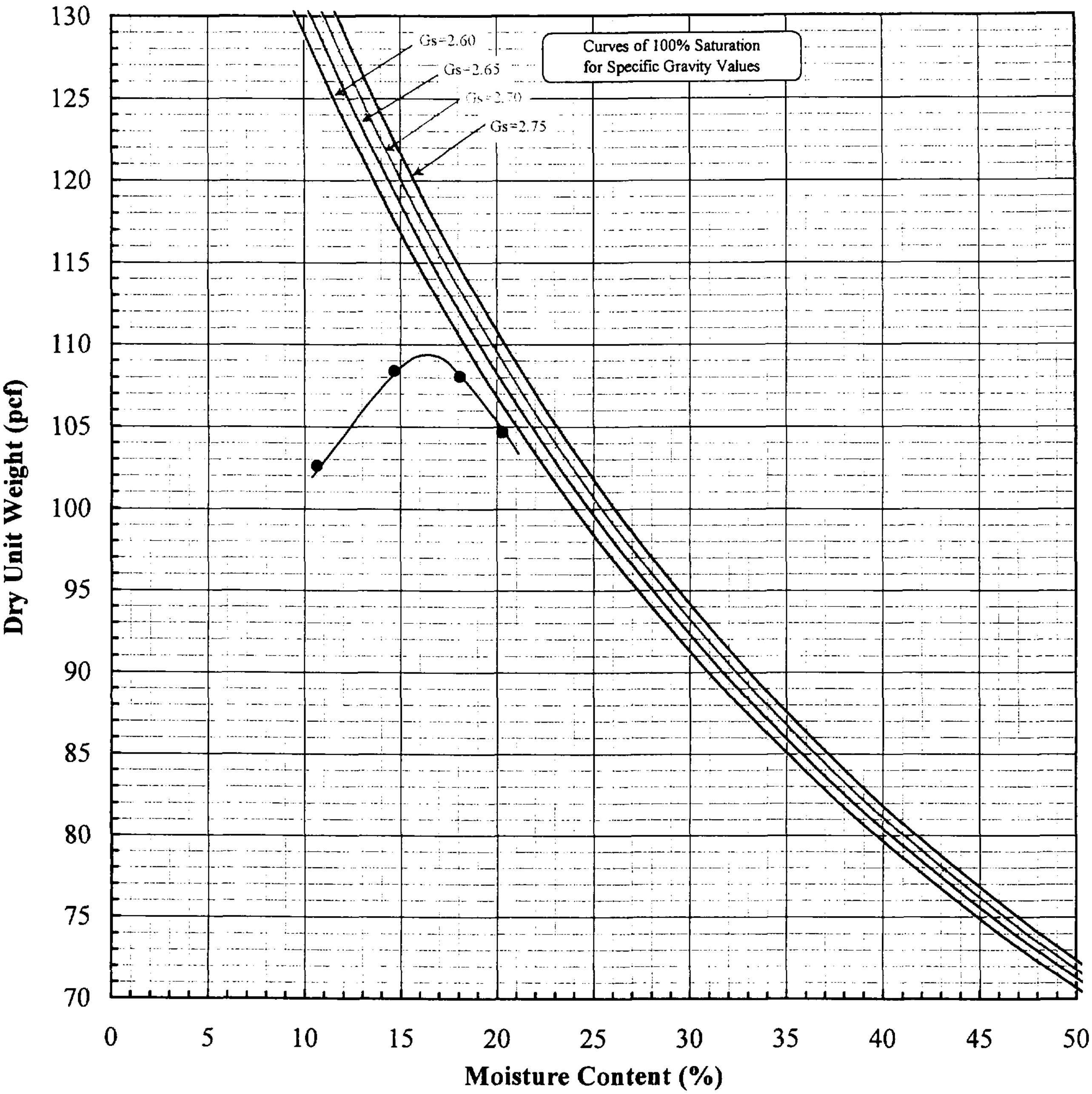
Note(s):

AL7852.Index.xls

Reviewed by: [signature] Date: 9/11/00
Cuneyt Gokmen, Program Manager

GEOSYNTEC CONSULTANTS Soil-Geosynthetic Interaction Testing Laboratory 5775 Peachtree Dunwoody Road, Suite 11D, Atlanta, Georgia 30342 Ph: (404) 705 9500 Fax: (404) 705 9300	
Project Name:	Sauget Area 1 TSCA LF
Project No:	GLI1096
Client Sample ID:	Clay Liner Soil No. 1
Lab Sample No:	AL7852

ASTM D698 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** **Standard - Method A**



Client Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
Clay Liner Soil No. 1	AL7852	109.5	16.1	

Note(s):

AL7852.Proctor.xls

Reviewed by: [signature] Date: 9/11/00
Cuneyt Gokmen, Program Manager

GEOSYNTEC CONSULTANTS
Soil-Geosynthetic Interaction Testing Laboratory
5775 Peachtree Dunwoody Road, Suite 11D, Atlanta, Georgia 30342
Ph: (404) 705 9500 Fax: (404) 705 9300

FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	Sauget Area 1 TSCA LF
Project Number:	GLI1096
Client Project Number:	URS Job No. C100003899.00
Client/Site ID:	Clay Liner Soil No. 1
Sample Number:	AL7852
Material Type:	SOIL
Expected/Specified Value:	1E-7 cm/s

Specimen	Test Specimen Initial Conditions					Test Conditions					Hydraulic
No.	Spec. Prep. (2) (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid (3) (-)	Average Gradient (-)	Conductivity (cm/s)
1	R	5.78	7.27	104.4	16.2	90.0	75.0	15.0	DTW	9.5	1.3E-5
2	R	5.76	7.25	104.4	19.3	90.0	75.0	15.0	DTW	9.1	2.0E-6

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water

* Deviations:
Laboratory temperature at 21±3 °C.
Test specimen final conditions are not presented.

Reviewed by: [signature] Date: 9/11/00
Cuneyt Gokmen, Program Manager

AL7852.1&2.FW5084.xls

GEOSYNTEC CONSULTANTS

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Web Site: www.interactionspecialists.com

January 2, 2001

Mr. Gary M. Wantland, P.E.
URS Greiner Woodward-Clyde
7650 West Courtney Campbell Causeway
Tampa, Florida 33607

Subject: Laboratory Test Results Transmittal
Soil Index, Compaction and Permeability Testing
Sample: Clay Liner Soil No. 1

Dear Mr. Wantland;

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Sincerely,

Cuneyt Gokmen
Program Manager

Robert H. Swan, Jr.
Laboratory Manager

Attachment

Notes:
(1) Unless otherwise noted in the test results the sample(s)/specimen(s) were prepared in accordance with the applicable test standards or generally accepted sampling procedures.
(2) Contaminated/chemical samples and all related laboratory generated waste (i.e., test liquids, PPE, absorbents, etc.) will be returned to the client or designated representative(s), at the client's cost, within 60 days following the completion of the testing program, unless special arrangements for proper disposal are made with GeoSyntec.
(3) Materials that are not contaminated will be discarded after test specimens and archived specimens are obtained. Archived specimens will be discarded 60 days after the samples are received at the laboratory, unless long-term storage arrangements are specifically made with the laboratory.
(4) The reported results apply only to the materials and test conditions used in the laboratory testing program. The results do not necessarily apply to other materials or test conditions. The test results should not be used in engineering analysis unless the test conditions model the anticipated field conditions. The testing was performed in accordance with general engineering testing standards and requirements. The reported results are submitted for the exclusive use of the client to whom it is addressed.

GLI1096/SGI00203.TESTCOVLTR.DOC

SOIL

GEOSYNTEC CONSULTANTS
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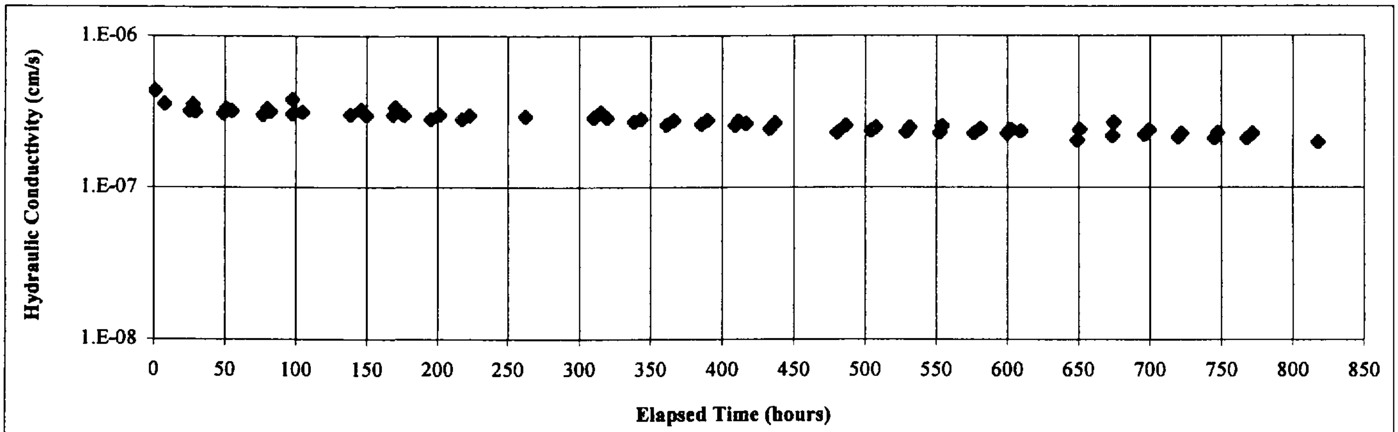
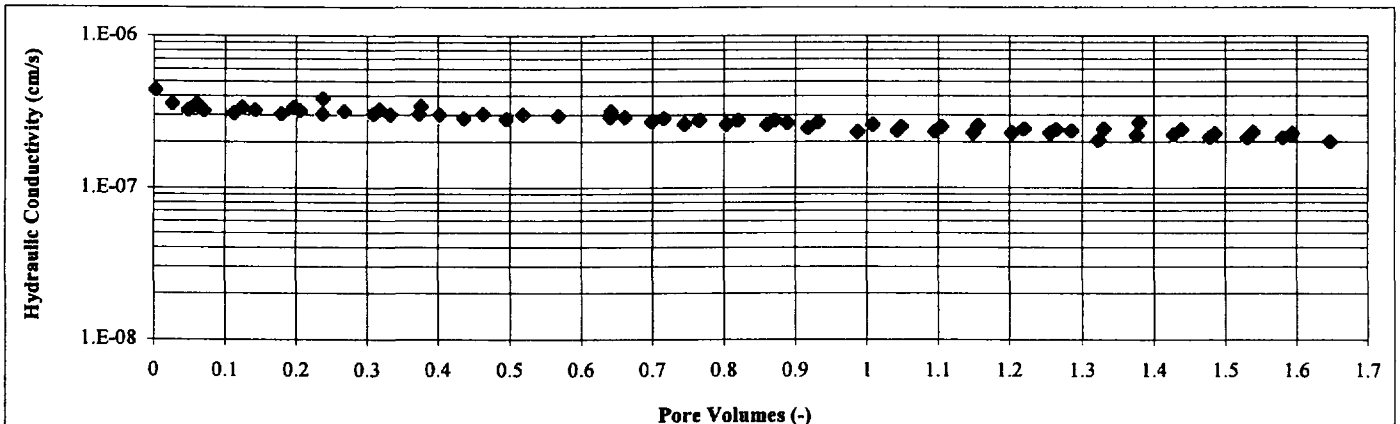
FLEXIBLE WALL PERMEABILITY TEST (1)
ASTM D5084 *

Project Name:	Solutia Site Compatibility Testing / Sauget Area 1 TSCA LF
Project Number:	GLI1096
Client Project Number:	C100003899
Client/Site ID:	Clay Liner Soil No. 1
Sample Number:	AL7852
Material Type:	Soil (Remolded)

Specimen No.	Initial Final	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Porosity (Note 2) (-)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid (3) (-)	Average Gradient (-)	Hydraulic Conductivity (Note 4) (cm/s)
	Test Specimen Conditions						Test Conditions					
1	Initial	7.56	7.17	103.9	19.3	0.38	75.7	60.7	15.0	SL	9.0	2.2E-7
	Final	7.54	7.12	105.2	22.0	0.36						





Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
   Test specimen was hydrated, saturated, consolidated and permeated with the project specific synthetic leachate.
2. For porosity and pore volume calculations, specific gravity was assumed to be 2.65.
3. Type of permeant liquid: SL = Project Specific Synthetic Leachate
4. Hydraulic conductivity value reported was calculated based on the average of the last eight measurements.

* Deviations:
Laboratory temperature at 21±3 °C.
AL7852.1.FWPerm.xls

Reviewed by: Date: 12/20/00
Cuneyt Gokmen, Program Manager

GCL

GEOSYNTEC CONSULTANTS
Soil-Geosynthetic Interaction Testing Laboratory

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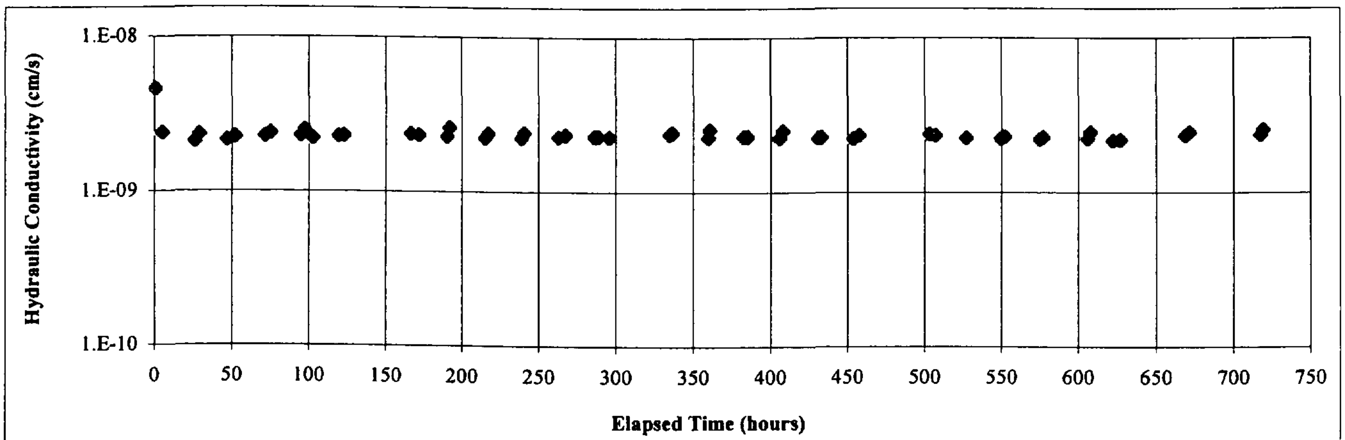
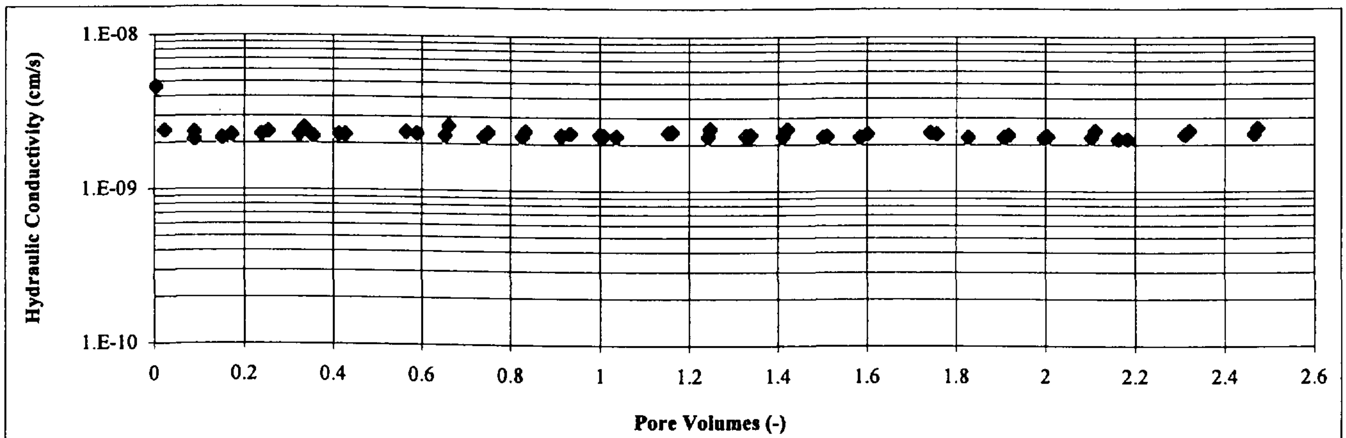
Ph: (404) 705 9500 Fax: (404) 705 9300

FLEXIBLE WALL PERMEABILITY TEST (1)
ASTM D5887 *

Project Name:	Solutia Site Compatibility Testing / Sauget Area 1 TSCA LF
Project Number:	GLI1096
Client Project Number:	C100003899
Client/Site ID:	Bentomat DN
Sample Number:	AL7854
Material Type:	GCL

Specimen No.	Test Specimen Conditions					Test Conditions					Hydraulic Conductivity (Note 4) (cm/s)
	Initial / Final	Spec. Thick. (cm)	Spec. Diameter (cm)	Moisture Content (%)	Porosity (Note 2) (-)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Influent Pressure (psi)	Permeant Liquid (3) (-)	
1	Initial	0.88	10.67	14.8	-	80.0	75.0	5.0	77.0	SL	2.3E-9
	Final	0.63	10.69	114.6	0.67						





Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
   Test specimen was hydrated, saturated, consolidated and permeated with the project specific synthetic leachate.
2. For porosity and pore volume calculations, specific gravity was assumed to be 2.65.
3. Type of permeant liquid: SL = Project Specific Synthetic Leachate
4. Hydraulic conductivity value reported was calculated based on the average of the last eight measurements.

* Deviations:
Laboratory temperature at 21±3 °C.
AL7854.1.FWPerm.xls

Reviewed by: [signature] Date: 12/27/00
Cuneyt Gokmen, Program Manager

GeoSyntec-SGI® Laboratory
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Atlanta, Georgia 30342 • USA
Tel. (404) 705-9500 • Fax (404) 705-9300
Web Site: www.interactionspecialists.com

GEOSYNTEC CONSULTANTS

January 2, 2001

Mr. Gary M. Wantland, P.E.
URS Greiner Woodward-Clyde
7650 West Courtney Campbell Causeway
Tampa, Florida 33607

Subject: Laboratory Test Results Transmittal
Geosynthetic Material Chemical Compatibility Testing
Samples: Geomembrane and Geotextile

Dear Mr. Wantland;

GeoSyntec Consultants (GeoSyntec) is pleased to present the attached test results for the above-mentioned project. The note section below addresses sample preparation, sample disposal and a disclosure statement.

GeoSyntec appreciates the opportunity to provide laboratory testing services for this project. Should you have any questions regarding the attached document(s), or if you require additional information, please do not hesitate to contact either of the undersigned.

Sincerely,

Cuneyt Gokmen
Program Manager

Robert H. Swan, Jr.
Laboratory Manager

Attachment

Notes:
(1) Unless otherwise noted in the test results the sample(s)/specimen(s) were prepared in accordance with the applicable test standards or generally accepted sampling procedures.
(2) Contaminated/chemical samples and all related laboratory generated waste (i.e., test liquids, PPE, absorbents, etc.) will be returned to the client or designated representative(s), at the client's cost, within 60 days following the completion of the testing program, unless special arrangements for proper disposal are made with GeoSyntec.
(3) Materials that are not contaminated will be discarded after test specimens and archived specimens are obtained. Archived specimens will be discarded 60 days after the samples are received at the laboratory, unless long-term storage arrangements are specifically made with the laboratory.
(4) The reported results apply only to the materials and test conditions used in the laboratory testing program. The results do not necessarily apply to other materials or test conditions. The test results should not be used in engineering analysis unless the test conditions model the anticipated field conditions. The testing was performed in accordance with general engineering testing standards and requirements. The reported results are submitted for the exclusive use of the client to whom it is addressed.

GLI1096/SGI00198.TESTCOVLTR.DOC

GEOMEMBRANE

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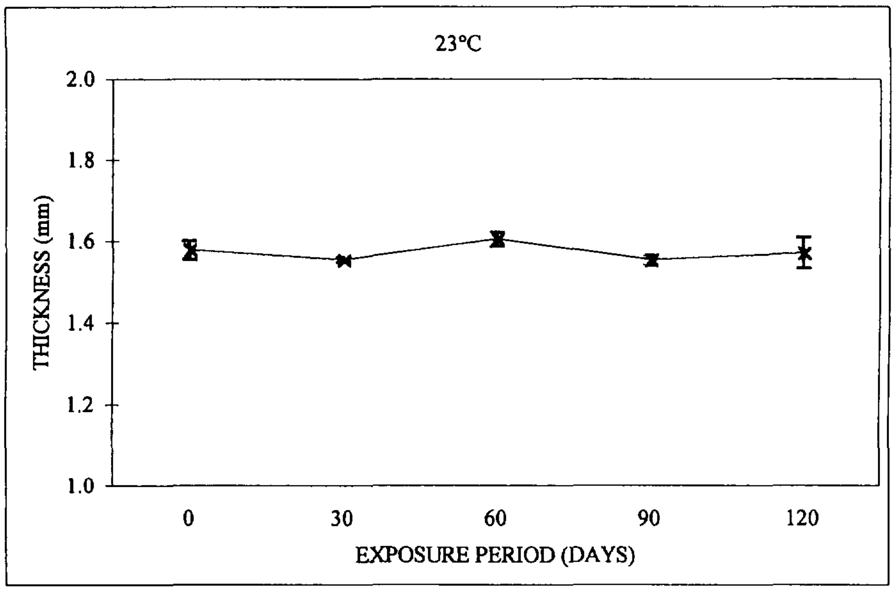
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

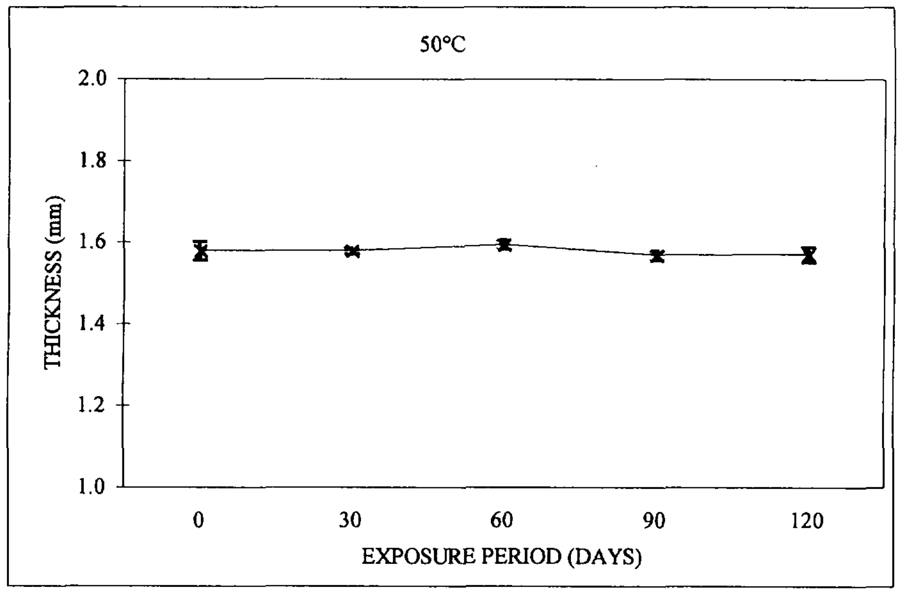
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 5199

PROPERTY (UNIT): THICKNESS (mm)
DIRECTION: N/A

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens								Specimens								
	1	2	3	4	5	Mean	Standard Deviation	Percent Change	1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	1.56	1.62	1.57	1.58	1.57	1.58	0.02	0.0	1.56	1.62	1.57	1.58	1.57	1.58	0.02	0.0	
30	1.56	1.56	1.55	1.55		1.56	0.01	-1.6	1.58	1.59	1.58	1.57		1.58	0.01	0.0	
60	1.62	1.59	1.60	1.63		1.61	0.02	1.7	1.60	1.59	1.59	1.61		1.60	0.01	1.0	
90	1.54	1.55	1.57	1.56		1.56	0.01	-1.6	1.56	1.56	1.58	1.58		1.57	0.01	-0.6	
120	1.60	1.55	1.61	1.53		1.57	0.04	-0.5	1.60	1.56	1.56	1.57		1.57	0.02	-0.5	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

THICKNESS.SGI.xls

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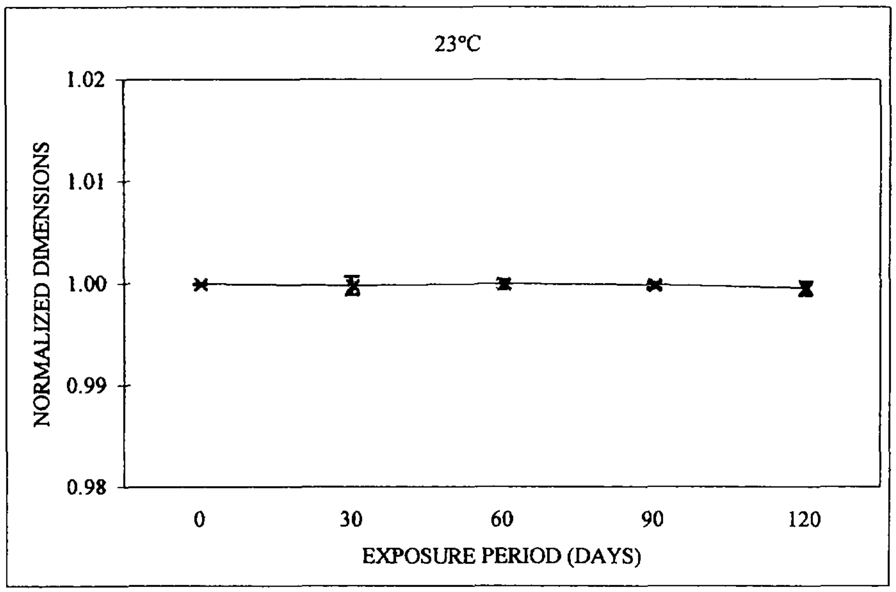
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

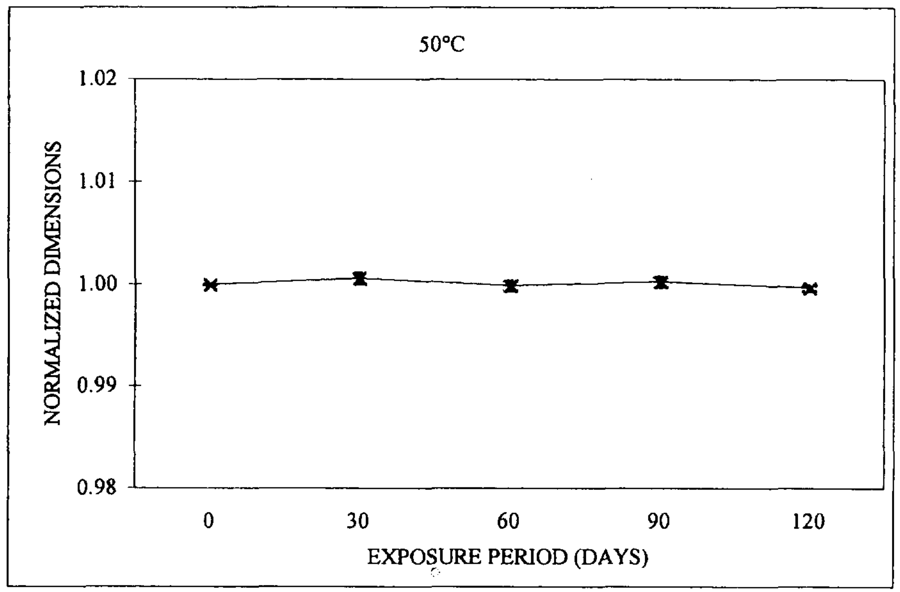
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: EPA 9090

PROPERTY (UNIT): NORMALIZED DIMENSIONS (FINAL LENGTH/INITIAL LENGTH)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	1.0000	1.0000	1.0000	1.0000		1.0000	0.0000	0.00	1.0000	1.0000	1.0000	1.0000		1.0000	0.0000	0.00	
30	1.0004	0.9985	1.0000	1.0004		0.9998	0.0009	-0.02	1.0001	1.0007	1.0002	1.0013		1.0006	0.0005	0.06	
60	0.9993	1.0003	1.0001	1.0002		1.0000	0.0005	0.00	1.0003	0.9997	0.9993	1.0003		0.9999	0.0005	-0.01	
90	0.9996	0.9996	1.0000	1.0002		0.9999	0.0003	-0.01	1.0003	1.0007	0.9996	1.0005		1.0003	0.0005	0.03	
120	0.9992	1.0001	1.0001	0.9988		0.9996	0.0007	-0.04	0.9996	0.9997	1.0001	0.9994		0.9997	0.0003	-0.03	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

DIMENSIONS.SGI.xls

GEOSYNTEC CONSULTANTS
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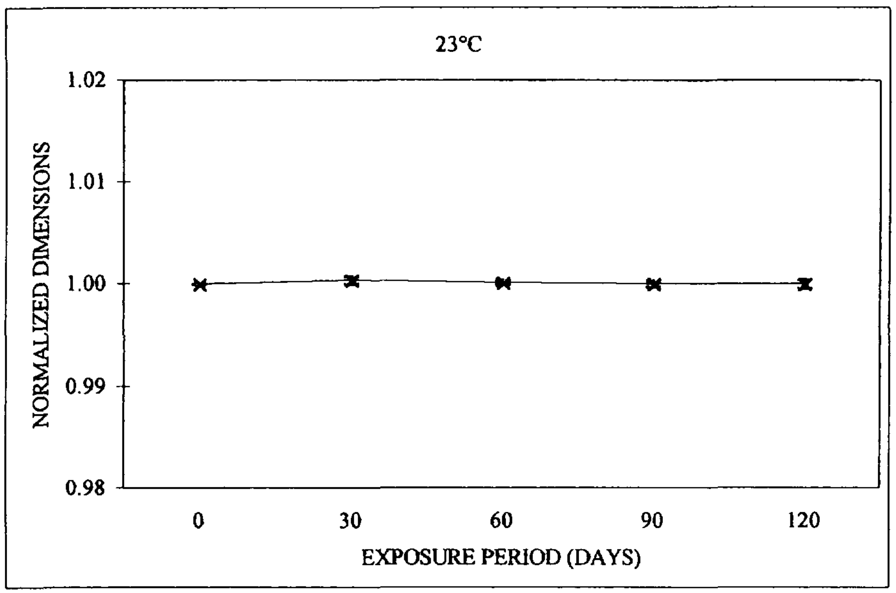
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

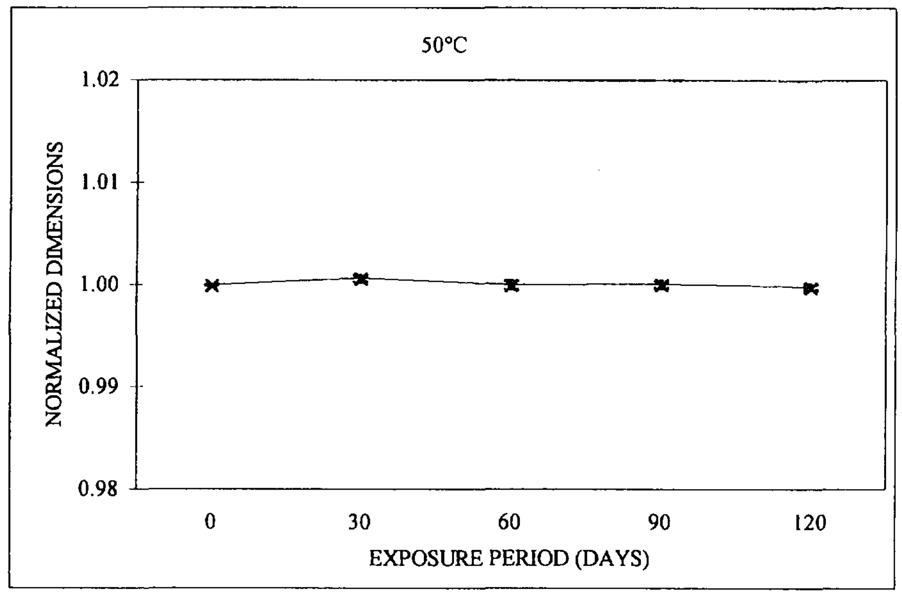
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: EPA 9090

PROPERTY (UNIT): NORMALIZED DIMENSIONS (FINAL LENGTH/INITIAL LENGTH)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	50°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Remarks
Control	1.0000	1.0000	1.0000	1.0000		1.0000	0.0000	0.00	1.0000	1.0000	1.0000	1.0000		1.0000	0.0000	0.00	
30	1.0008	1.0004	1.0003	0.9999		1.0004	0.0004	0.04	1.0010	1.0002	1.0005	1.0008		1.0006	0.0004	0.06	
60	1.0003	0.9998	1.0002	1.0003		1.0001	0.0002	0.01	1.0005	0.9995	1.0003	0.9998		1.0000	0.0005	0.00	
90	1.0003	1.0000	1.0002	0.9996		1.0000	0.0003	0.00	1.0003	1.0005	0.9997	0.9999		1.0001	0.0004	0.01	
120	0.9998	1.0004	0.9995	1.0003		1.0000	0.0004	0.00	0.9995	1.0001	1.0001	0.9998		0.9999	0.0003	-0.01	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

DIMENSIONS.SGI.xls

GEOSYNTEC CONSULTANTS
Soil-Geosynthetic Interaction Testing Laboratory
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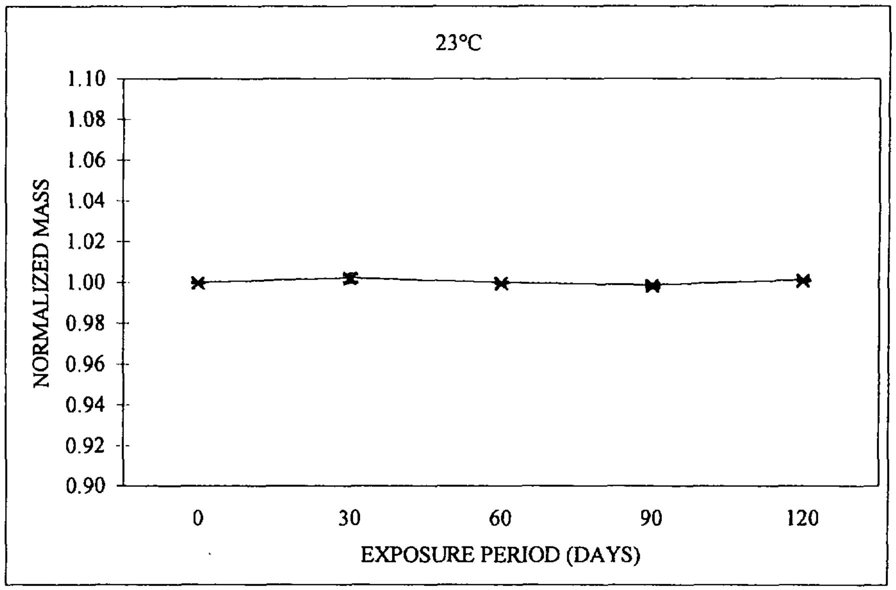
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

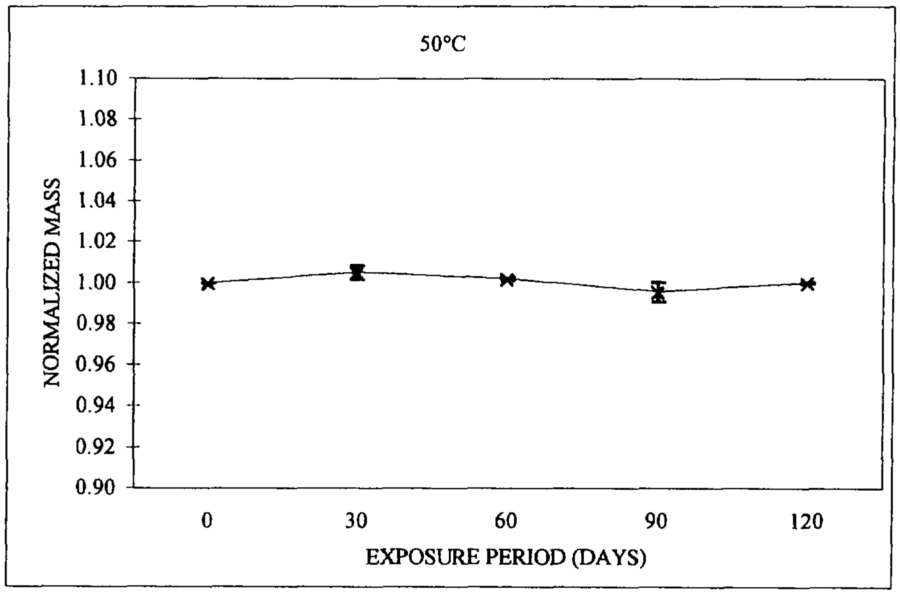
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: EPA 9090

PROPERTY (UNIT): NORMALIZED MASS (FINAL MASS/INITIAL MASS)
DIRECTION: N/A

Exposure Period (Days)	23°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	50°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Remarks
Control	1.0000	1.0000				1.0000	0.0000	0.00	1.0000	1.0000				1.0000	0.0000	0.00	
30	1.0007	1.0034				1.0021	0.0019	0.21	1.0027	1.0075				1.0051	0.0034	0.51	
60	1.0000	0.9997				0.9998	0.0002	-0.02	1.0027	1.0017				1.0022	0.0007	0.22	
90	0.9990	0.9976				0.9983	0.0010	-0.17	0.9990	0.9923				0.9957	0.0047	-0.43	
120	1.0010	1.0007				1.0008	0.0002	0.08	1.0000	1.0003				1.0002	0.0002	0.02	





Note: Error bars represent one standard deviation at mean sample value.

MASS.SGI.xls

Reviewed by: [signature] Date: 12/21/00
Cuneyt Gokmen, Program Manager

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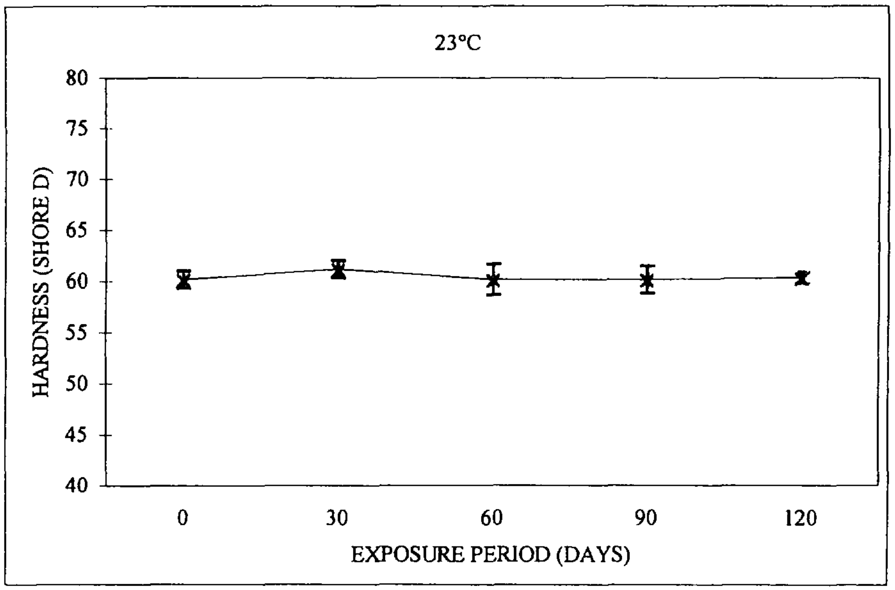
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

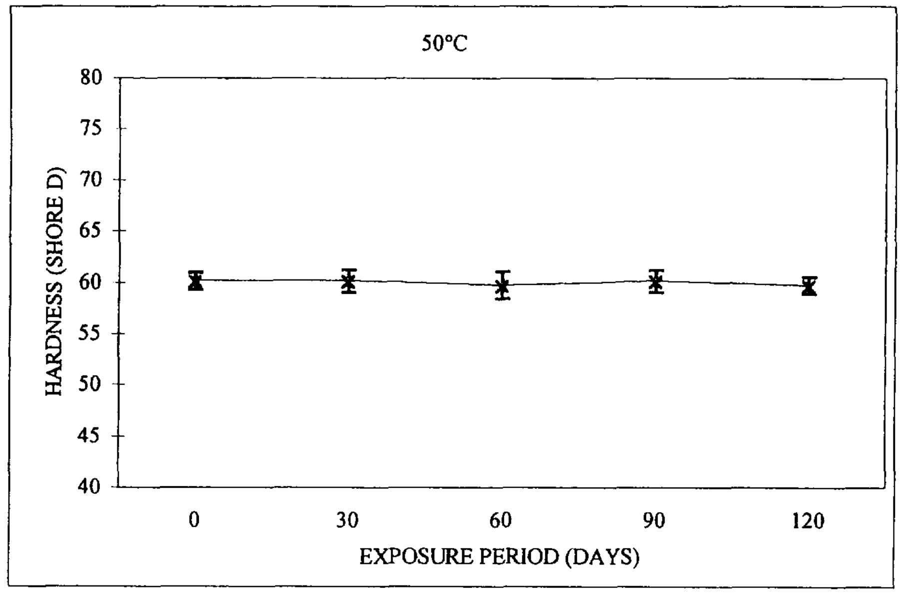
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 2240

PROPERTY (UNIT): HARDNESS (SHORE D)
DIRECTION: N/A

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	60	61	60	61	59	60.2	0.8	0.0	60	61	60	61	59	60.2	0.8	0.0	
30	61	62	60	61	62	61.2	0.8	1.7	60	60	62	60	59	60.2	1.1	0.0	
60	58	62	60	61	60	60.2	1.5	0.0	59	61	61	58	60	59.8	1.3	-0.7	
90	62	61	59	59	60	60.2	1.3	0.0	60	60	62	60	59	60.2	1.1	0.0	
120	60	61	61	60	60	60.4	0.5	0.3	59	59	60	60	61	59.8	0.8	-0.7	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

HARDNESS.SGI.xls

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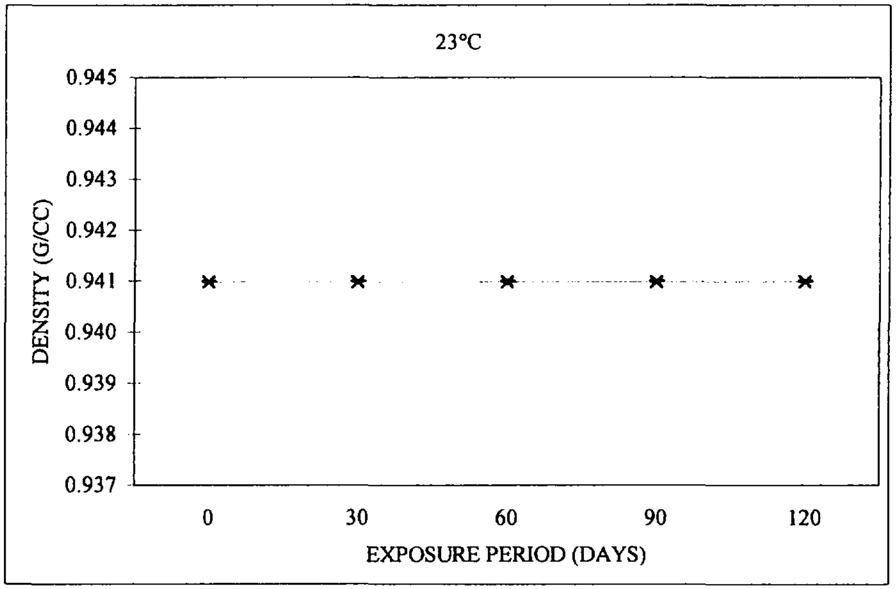
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

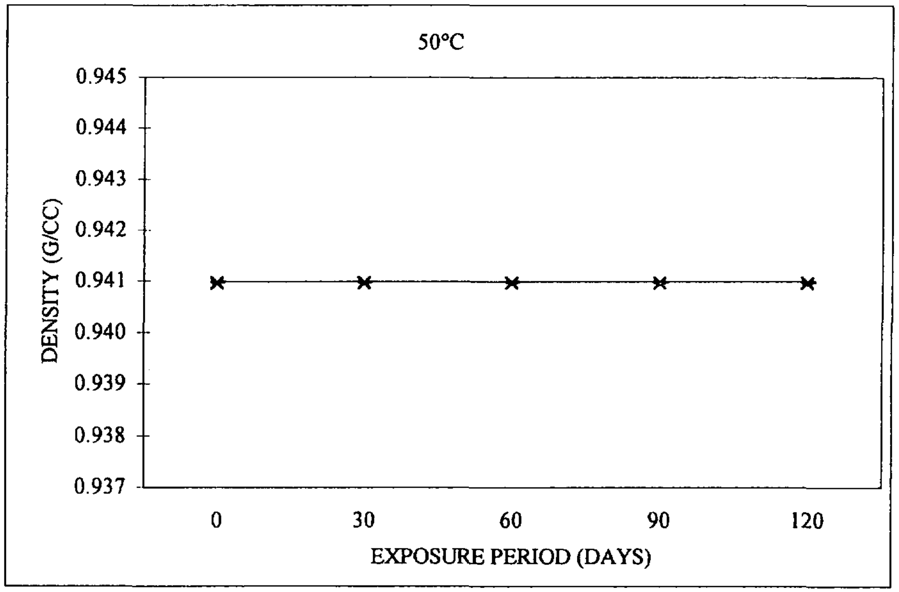
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 1505

PROPERTY (UNIT): DENSITY (G/CC)
DIRECTION: N/A

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	0.941	0.941	0.941			0.941	0.000	0.0	0.941	0.941	0.941			0.941	0.000	0.0	
30	0.941	0.941	0.941			0.941	0.000	0.0	0.941	0.941	0.941			0.941	0.000	0.0	
60	0.941	0.941	0.941			0.941	0.000	0.0	0.941	0.941	0.941			0.941	0.000	0.0	
90	0.941	0.941	0.941			0.941	0.000	0.0	0.941	0.941	0.941			0.941	0.000	0.0	
120	0.941	0.941	0.941			0.941	0.000	0.0	0.941	0.941	0.941			0.941	0.000	0.0	





Note: Error bars represent one standard deviation at mean sample value.

DENSITY.SGI.xls

Reviewed by: [signature] Date: 12/21/00
Cuneyt Gokmen, Program Manager

GEOSYNTEC CONSULTANTS

Soil-Geosynthetic Interaction Testing Laboratory

5775 Peachtree Dunwoody Road, Suite 11D, Atlanta, Georgia 30342
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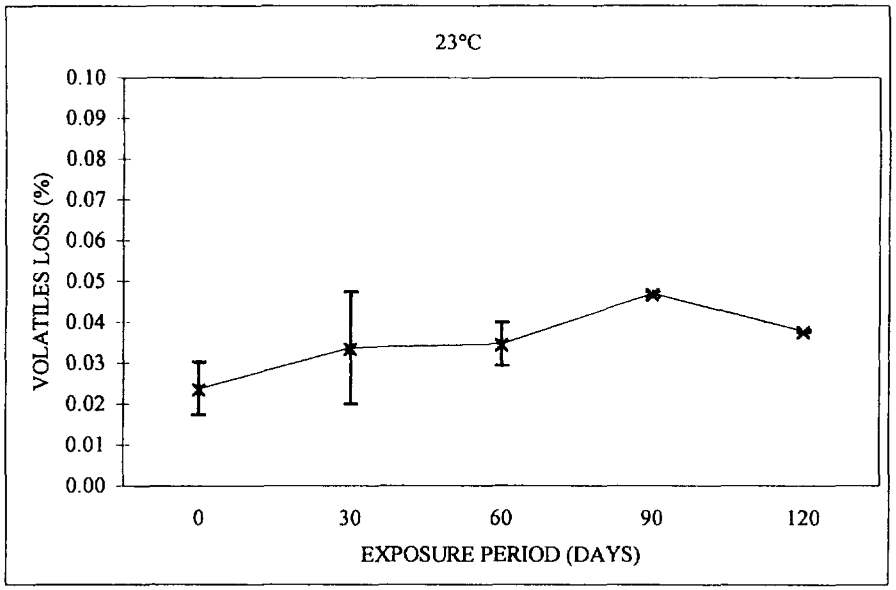
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

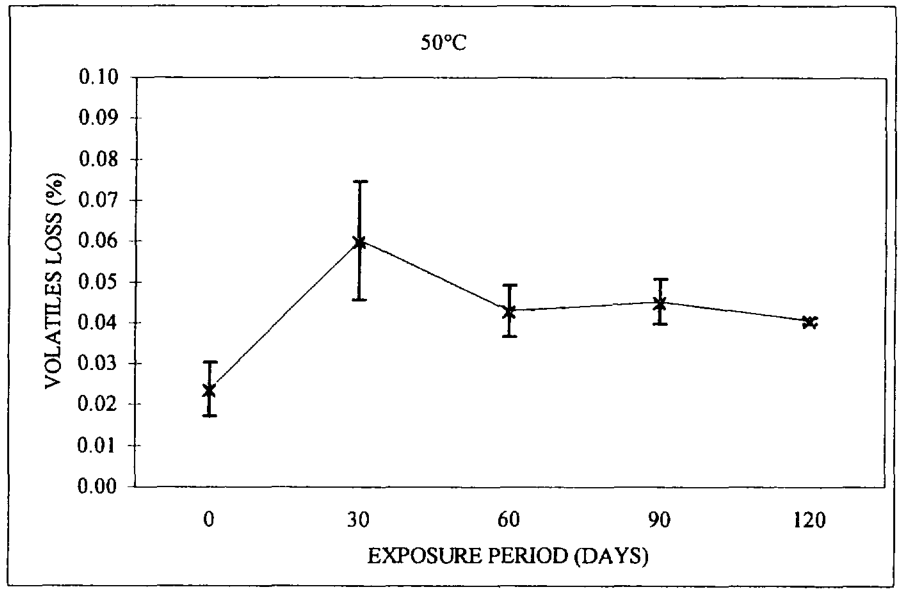
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: EPA 9090

PROPERTY (UNIT): VOLATILES LOSS (%)
DIRECTION: N/A

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	0.0192	0.0284				0.0238	0.0065	0.0	0.0192	0.0284				0.0238	0.0065	0.0	
30	0.0240	0.0435				0.0338	0.0138	41.8	0.0499	0.0704				0.0602	0.0145	152.7	
60	0.0309	0.0384				0.0347	0.0053	45.6	0.0386	0.0475				0.0431	0.0063	80.9	
90	0.0475	0.0465				0.0470	0.0007	97.5	0.0492	0.0414				0.0453	0.0055	90.3	
120	0.0380	0.0377				0.0379	0.0002	59.0	0.0413	0.0402				0.0408	0.0008	71.2	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/27/00
Cuneyt Gokmen, Program Manager

VOLATILES.SGI.xls

GEOSYNTEC CONSULTANTS
Soil-Geosynthetic Interaction Testing Laboratory
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Ph: (404) 705 9500 Fax: (404) 705 9300

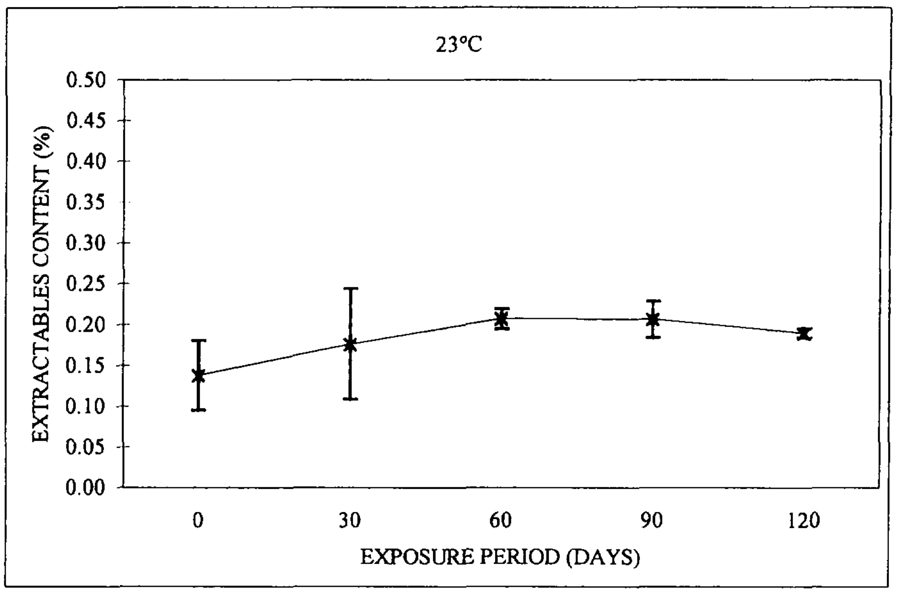
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

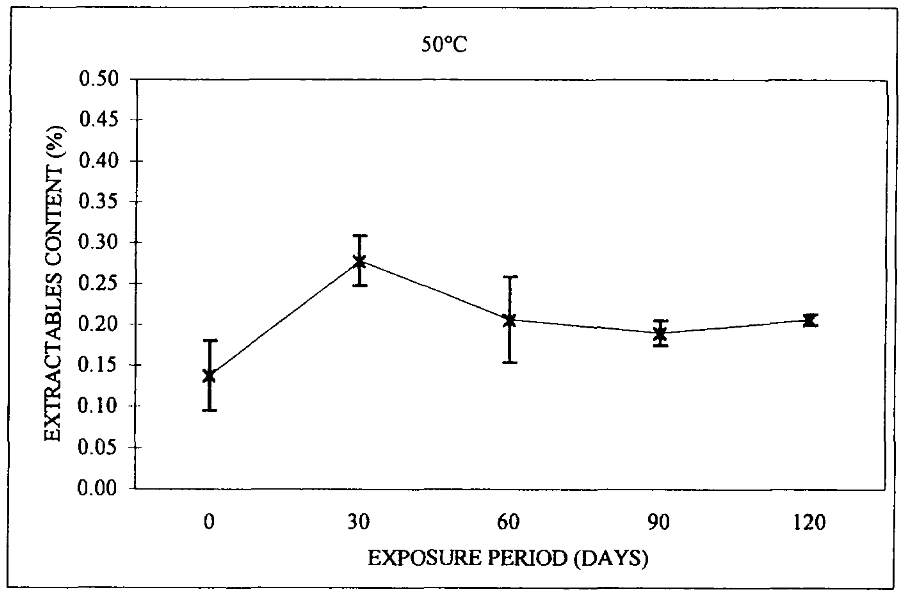
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: EPA 9090

PROPERTY (UNIT): EXTRACTABLES CONTENT (%)
DIRECTION: N/A

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	0.1682	0.1079				0.1381	0.0426	0.0	0.1682	0.1079				0.1381	0.0426	0.0	
30	0.1281	0.2236				0.1759	0.0675	27.4	0.2995	0.2563				0.2779	0.0305	101.3	
60	0.2162	0.1985				0.2074	0.0125	50.2	0.2427	0.1689				0.2058	0.0522	49.1	
90	0.2219	0.1903				0.2061	0.0223	49.3	0.2008	0.1794				0.1901	0.0151	37.7	
120	0.1851	0.1933				0.1892	0.0058	37.1	0.2016	0.2112				0.2064	0.0068	49.5	





Note: Error bars represent one standard deviation at mean sample value.

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EXTRACTABLES.SGI.xls

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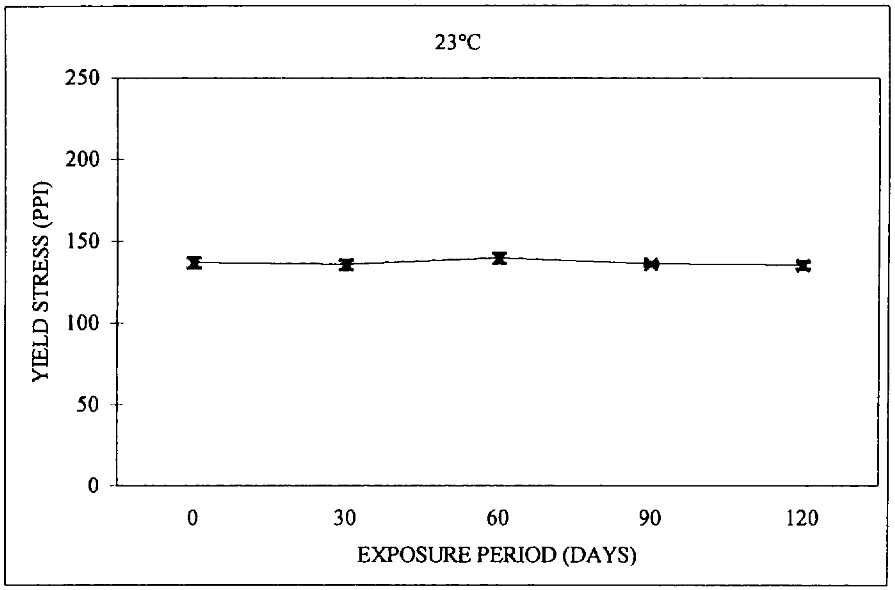
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

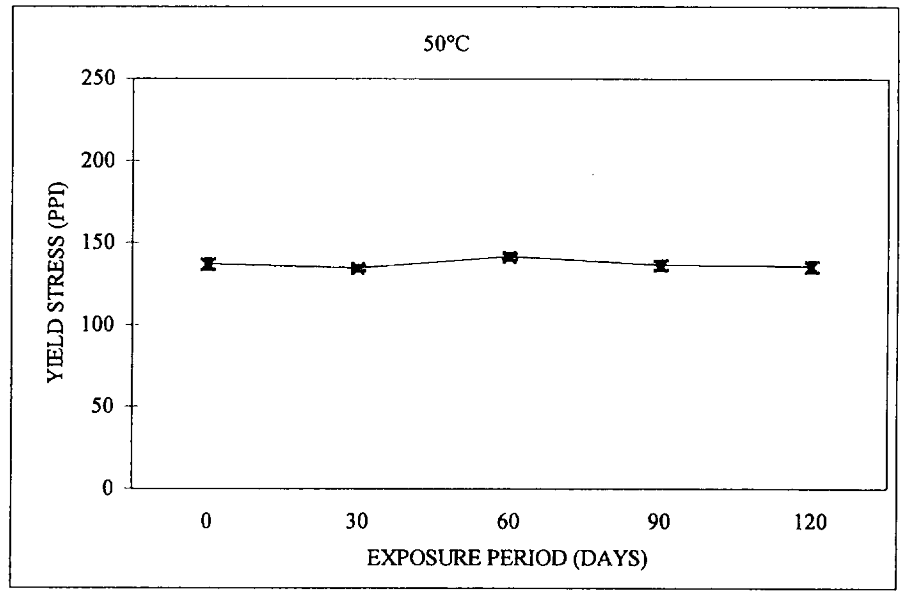
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): YIELD STRESS (PPI)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	139.7	138.2	139.7	132.6	135.2	137.1	3.1	0.0	139.7	138.2	139.7	132.6	135.2	137.1	3.1	0.0	
30	139.2	137.2	132.6	134.1		135.8	3.0	-0.9	137.2	135.2	134.1	133.6		135.0	1.6	-1.5	
60	136.3	143.9	140.8	138.4		139.8	3.3	2.0	141.0	143.2	139.5	143.8		141.9	2.0	3.5	
90	136.0	134.7	137.0	137.4		136.3	1.2	-0.6	136.2	138.4	139.3	133.1		136.7	2.7	-0.2	
120	135.0	138.4	132.9	136.0		135.6	2.3	-1.1	138.2	133.2	132.8	139.4		135.9	3.4	-0.9	





Note: Error bars represent one standard deviation at mean sample value.

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Reviewed by: Date: 12/28/00
Cuneyt Gokmen, Program Manager

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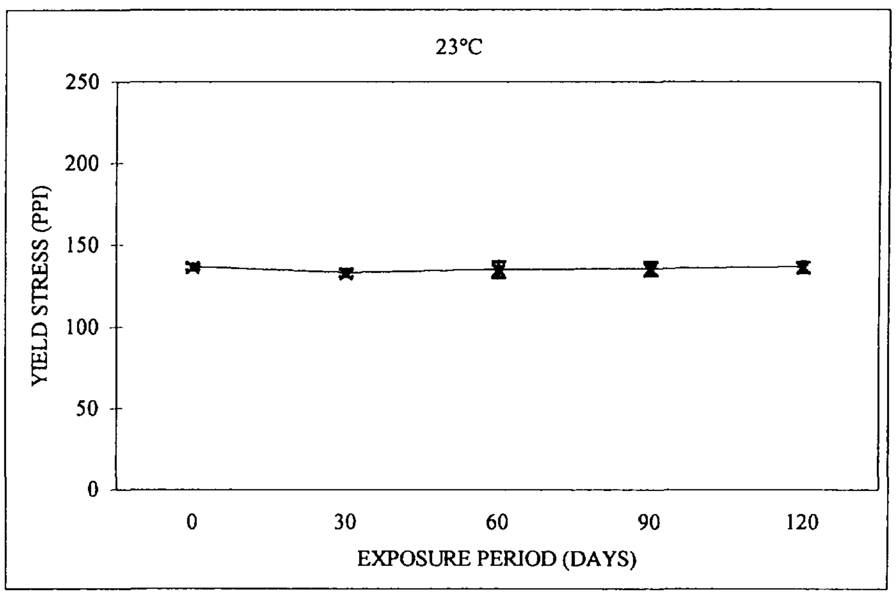
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

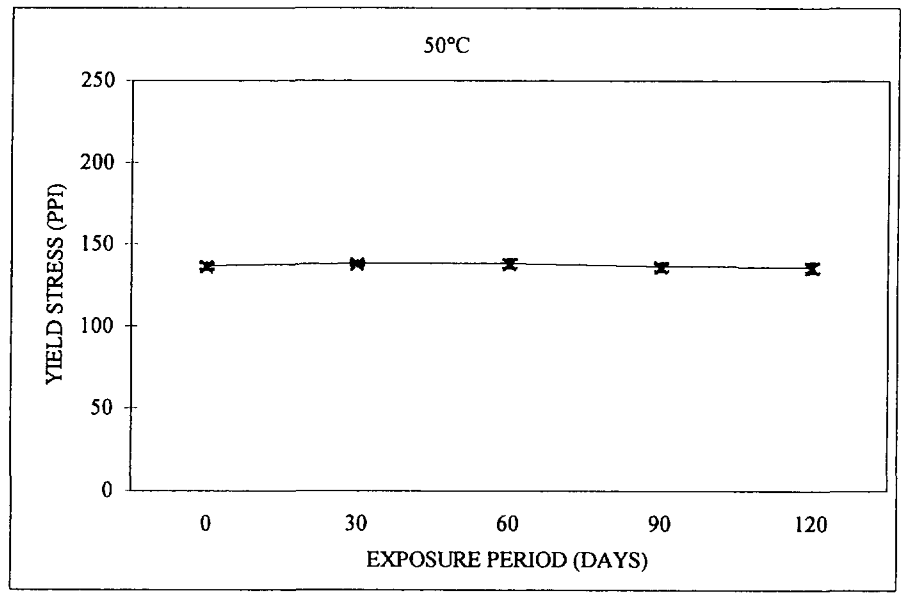
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): YIELD STRESS (PPI)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	139.2	138.7	135.7	135.2	135.7	136.9	1.9	0.0	139.2	138.7	135.7	135.2	135.7	136.9	1.9	0.0	
30	130.1	132.6	133.6	135.7		133.0	2.3	-2.9	140.3	138.7	137.7	137.7		138.6	1.2	1.2	
60	141.0	137.5	130.9	130.4		134.9	5.2	-1.4	141.1	134.7	139.7	138.3		138.5	2.7	1.1	
90	141.5	135.6	131.9	132.9		135.5	4.3	-1.0	140.0	136.2	134.7	134.5		136.4	2.5	-0.4	
120	139.5	138.6	135.0	132.3		136.4	3.3	-0.4	139.2	133.2	137.2	134.1		135.9	2.8	-0.7	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: [signature] Date: 12/28/00
Cuneyt Gokmen, Program Manager

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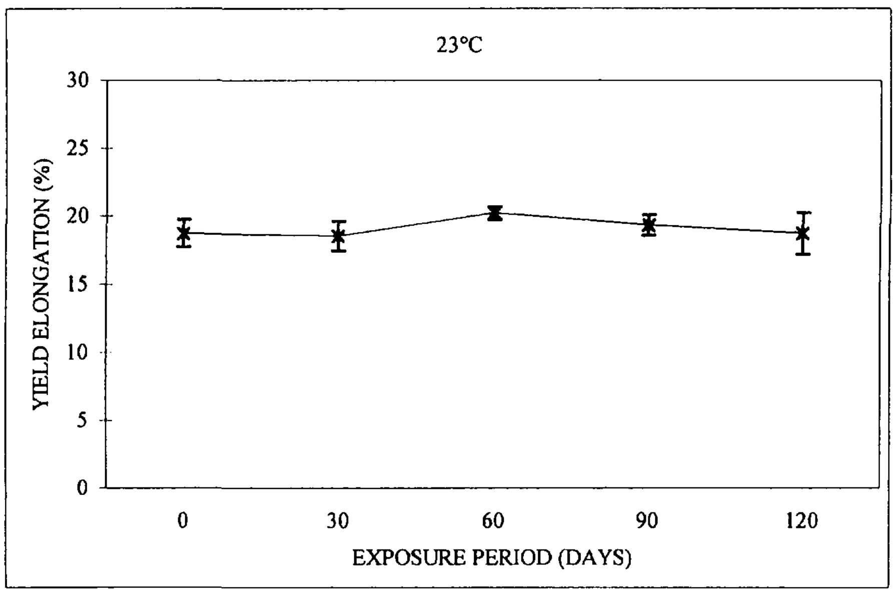
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

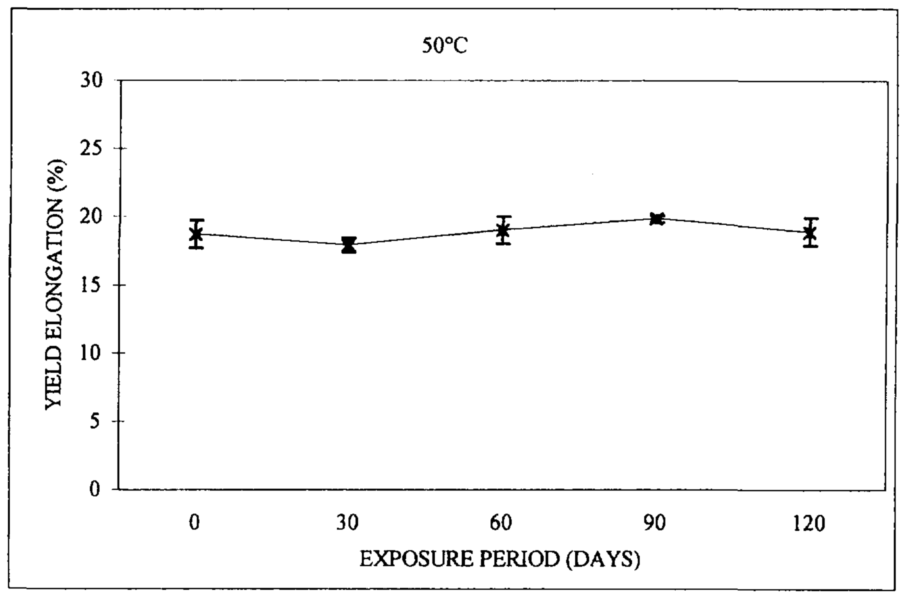
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): YIELD ELONGATION (%)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	18.18	18.71	19.80	19.67	17.42	18.76	1.01	0.0	18.18	18.71	19.80	19.67	17.42	18.76	1.01	0.0	
30	18.39	17.36	18.58	19.96		18.57	1.07	-1.0	17.50	17.73	17.95	18.68		17.97	0.51	-4.2	
60	20.78	19.74	19.97	20.51		20.25	0.48	8.0	19.64	18.60	20.15	17.93		19.08	1.00	1.7	
90	19.72	19.74	18.21	19.75		19.36	0.76	3.2	19.88	19.62	20.24	19.88		19.91	0.25	6.1	
120	20.95	17.57	18.06	18.33		18.73	1.51	-0.2	19.97	19.08	19.23	17.57		18.96	1.01	1.1	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/28/00
Cuneyt Gokmen, Program Manager

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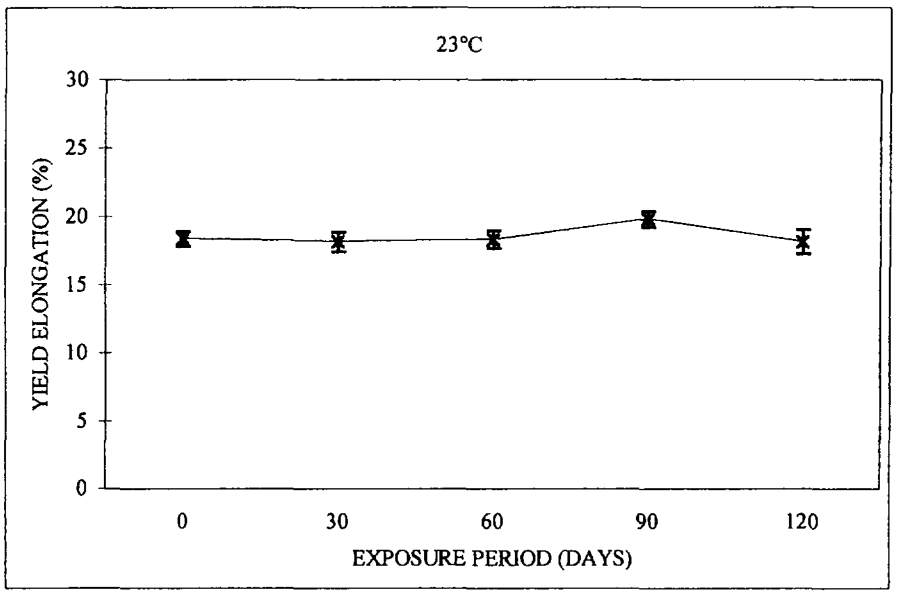
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

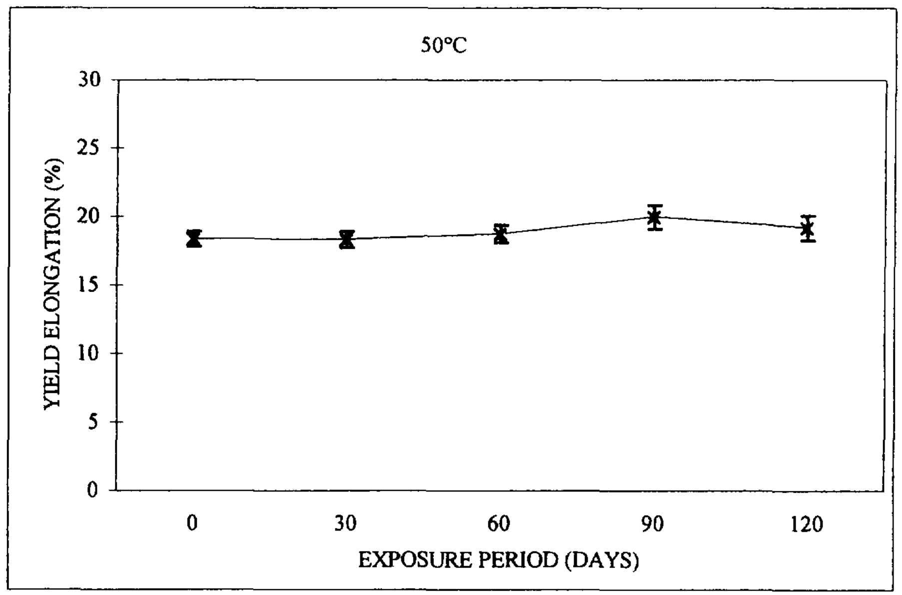
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): YIELD ELONGATION (%)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	18.70	18.91	17.98	18.67	17.65	18.38	0.54	0.0	18.70	18.91	17.98	18.67	17.65	18.38	0.54	0.0	
30	19.19	17.74	17.88	17.74		18.14	0.70	-1.3	19.18	18.03	18.39	17.77		18.34	0.61	-0.2	
60	18.08	17.55	19.13	18.47		18.31	0.67	-0.4	18.01	19.59	18.64	18.72		18.74	0.65	1.9	
90	19.11	20.54	19.76	19.74		19.79	0.59	7.6	19.66	18.95	20.81	20.57		20.00	0.86	8.8	
120	18.18	17.40	19.37	17.56		18.13	0.89	-1.4	19.12	20.43	18.22	19.11		19.22	0.91	4.6	





Note: Error bars represent one standard deviation at mean sample value.

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Cuneyt Gokmen, Program Manager

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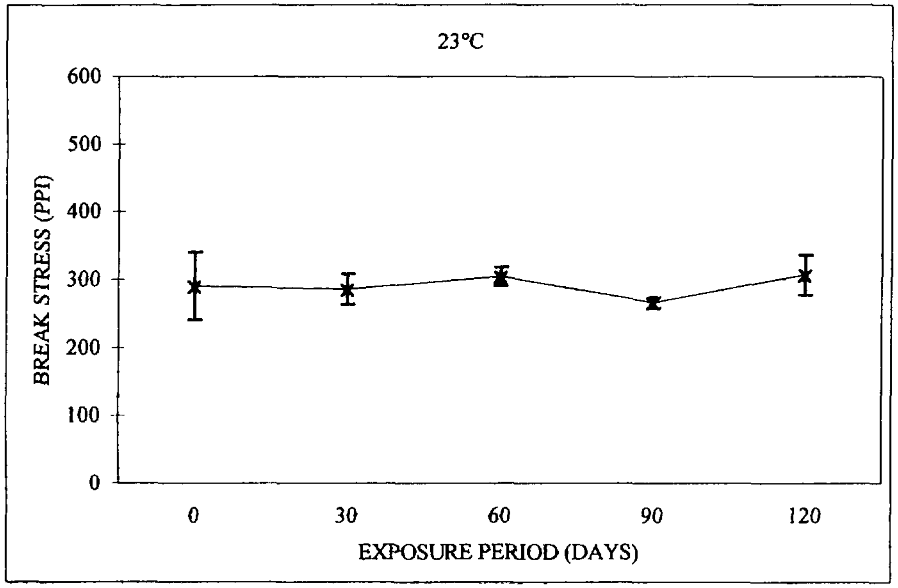
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

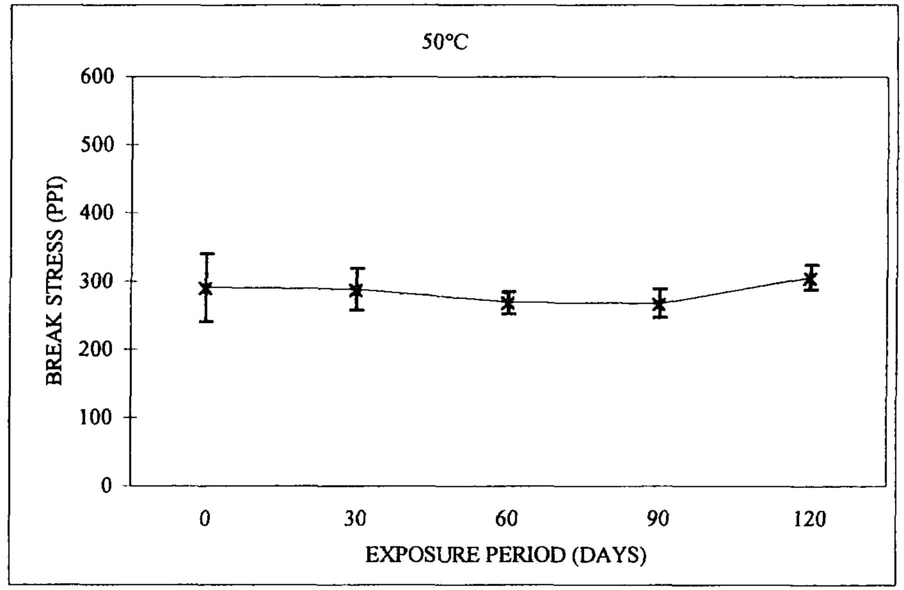
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): BREAK STRESS (PPI)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	307.9	279.7	208.9	326.2	330.8	290.7	49.9	0.0	307.9	279.7	208.9	326.2	330.8	290.7	49.9	0.0	
30	265.2	302.8	267.3	308.4		285.9	22.9	-1.6	321.2	300.3	283.0	248.0		288.1	31.0	-0.9	
60	304.6	324.5	297.0	293.8		305.0	13.8	4.9	265.8	254.4	263.7	293.0		269.2	16.6	-7.4	
90	278.8	262.2	261.3	264.1		266.6	8.2	-8.3	255.9	246.1	277.8	292.7		268.1	21.1	-7.8	
120	270.4	339.5	298.9	319.8		307.2	29.6	5.7	327.7	292.2	290.3	314.6		306.2	18.1	5.3	





Note: Error bars represent one standard deviation at mean sample value.

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Cuneyt Gokmen, Program Manager

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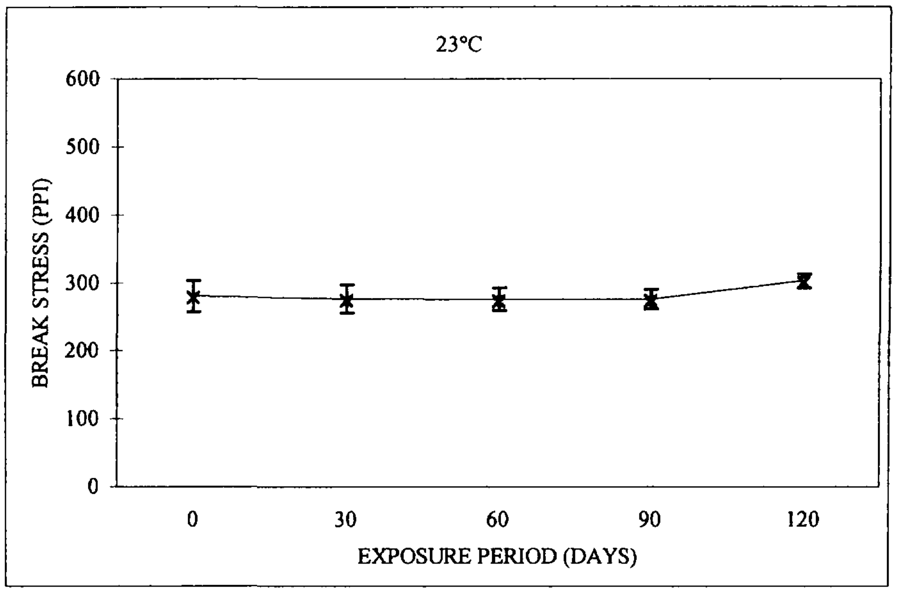
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

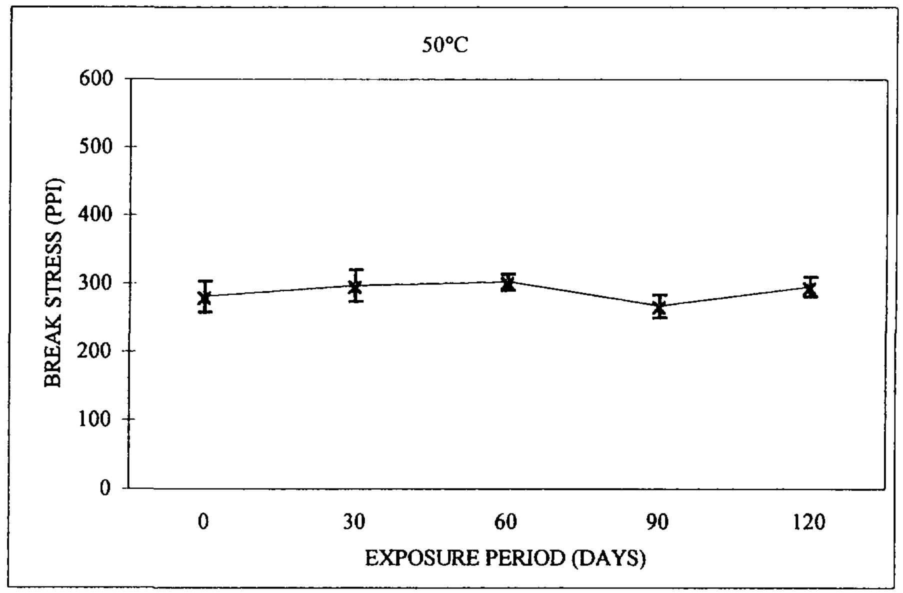
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): BREAK STRESS (PPI)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens					Mean	Standard Deviation	Percent Change	Specimens					Mean	Standard Deviation	Percent Change	
	1	2	3	4	5				1	2	3	4	5				
Control	288.1	273.4	316.1	257.6	267.0	280.4	22.8	0.0	288.1	273.4	316.1	257.6	267.0	280.4	22.8	0.0	
30	271.9	277.4	303.9	253.1		276.6	21.0	-1.4	327.2	292.7	270.8	296.2		296.7	23.2	5.8	
60	260.8	294.9	263.8	282.5		275.5	16.1	-1.8	298.9	308.6	286.9	315.3		302.4	12.3	7.8	
90	260.6	277.8	269.1	294.9		275.6	14.7	-1.7	284.4	276.6	246.9	259.2		266.8	16.9	-4.9	
120	287.4	308.0	310.1	303.6		302.3	10.3	7.8	291.8	276.4	303.8	308.5		295.1	14.3	5.2	





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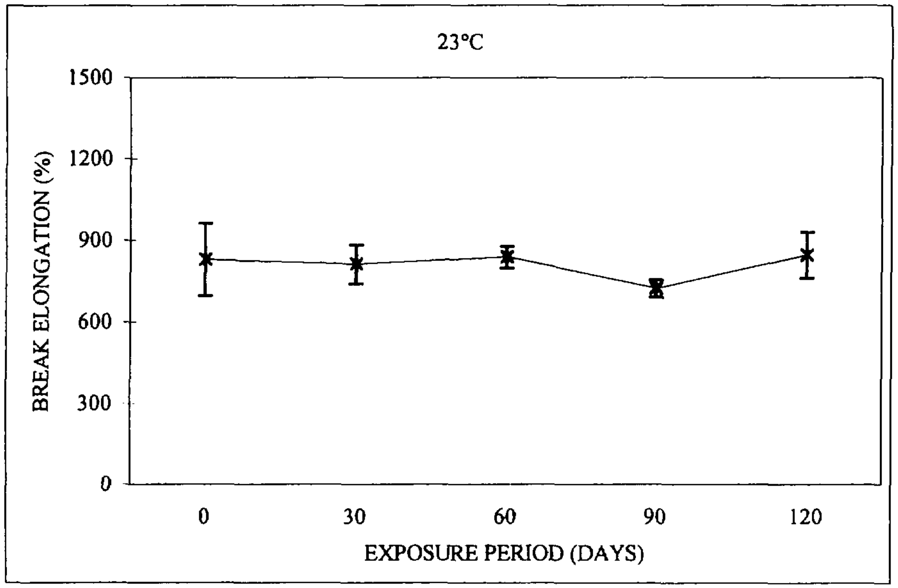
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

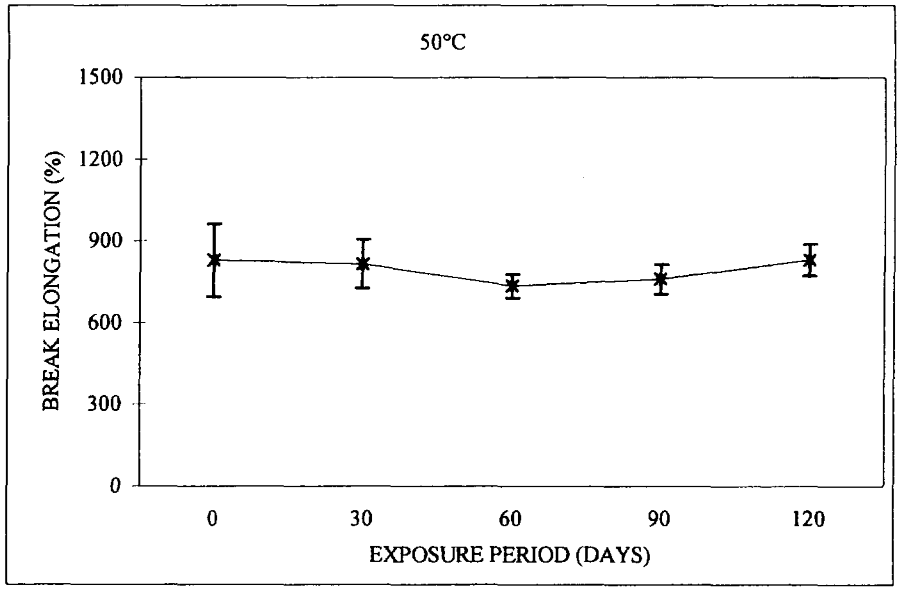
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): BREAK ELONGATION (%)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	871.7	939.0	823.6	602.6	910.7	829.5	134.1	0.0	871.7	939.0	823.6	602.6	910.7	829.5	134.1	0.0	
30	749.0	864.5	751.6	884.3		812.3	72.1	-2.1	914.0	853.2	801.8	701.5		817.6	90.0	-1.4	
60	843.4	894.2	817.0	803.8		839.6	40.0	1.2	726.5	698.2	723.2	800.5		737.1	44.1	-11.1	
90	768.8	696.2	705.4	724.6		723.7	32.3	-12.7	732.5	704.8	784.6	828.2		762.5	54.9	-8.1	
120	736.4	825.5	892.8	927.2		845.5	84.1	1.9	910.7	788.6	787.3	841.4		832.0	58.2	0.3	





Notes:
1. Break elongation values are calculated based on a gauge length of 50 mm (1.97 in.)
2. Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/28/00
Cuneyt Gokmen, Program Manager

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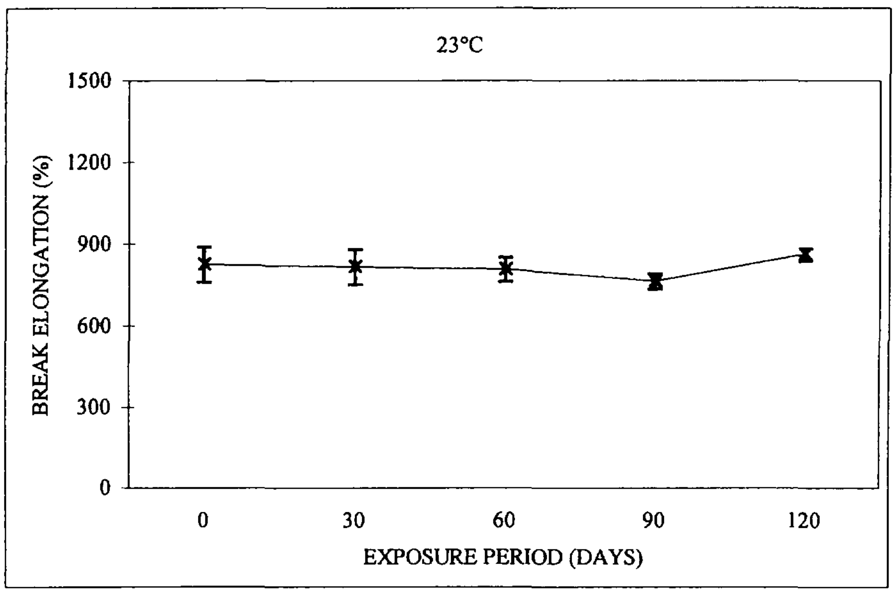
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

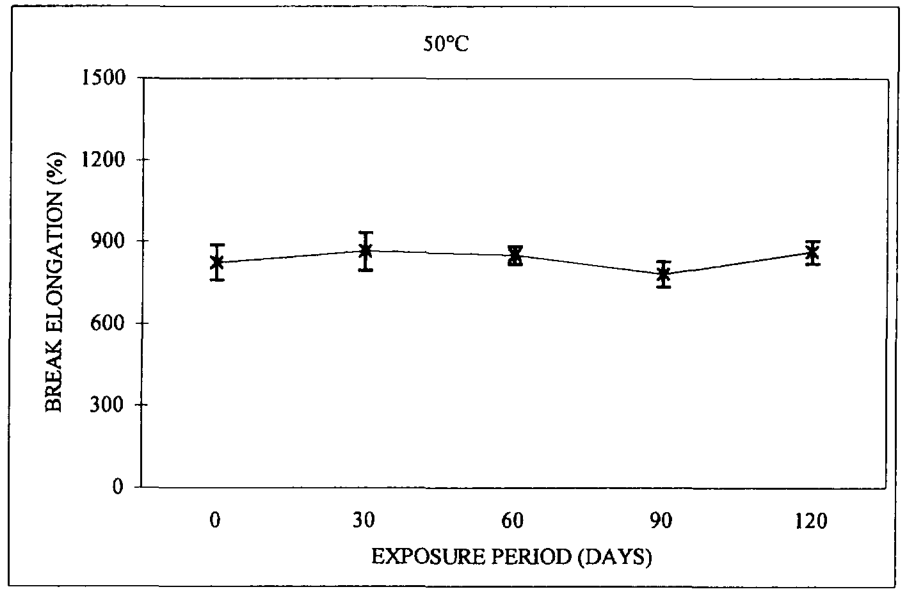
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): BREAK ELONGATION (%)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	840.1	810.4	926.5	764.2	778.7	823.9	64.4	0.0	840.1	810.4	926.5	764.2	778.7	823.9	64.4	0.0	
30	797.2	818.9	899.4	745.0		815.1	64.2	-1.1	956.9	850.6	790.6	861.8		865.0	68.8	5.0	
60	762.2	859.2	777.4	828.2		806.7	44.9	-2.1	841.4	860.5	811.7	890.9		851.1	33.3	3.3	
90	737.8	773.4	737.8	797.2		761.5	29.1	-7.6	824.9	817.0	730.5	755.6		782.0	46.2	-5.1	
120	827.5	865.8	877.0	869.1		859.8	22.1	4.4	845.3	813.7	892.2	901.4		863.1	41.1	4.8	





Notes:
1. Break elongation values are calculated based on a gauge length of 50 mm (1.97 in.)
2. Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/28/00
Cuneyt Gokmen, Program Manager

GEOSYNTEC CONSULTANTS
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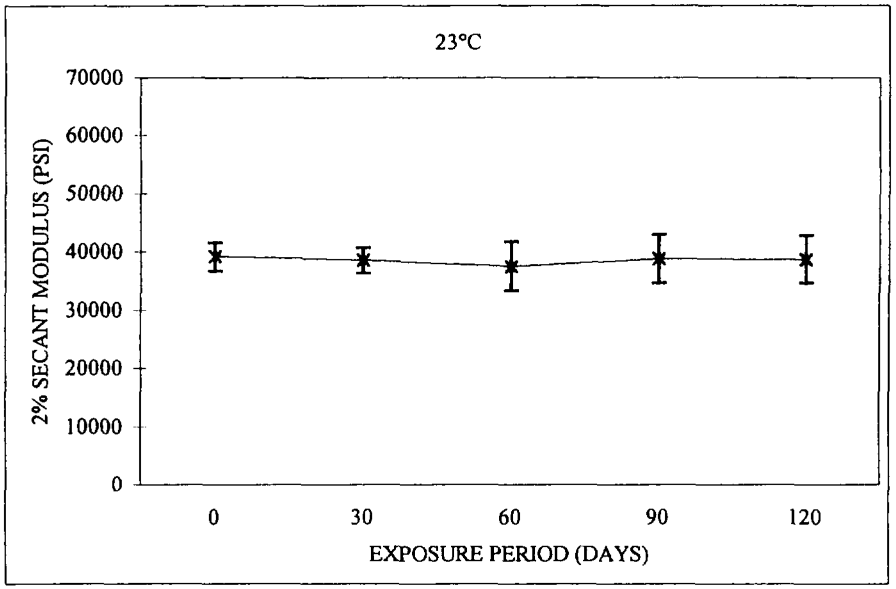
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

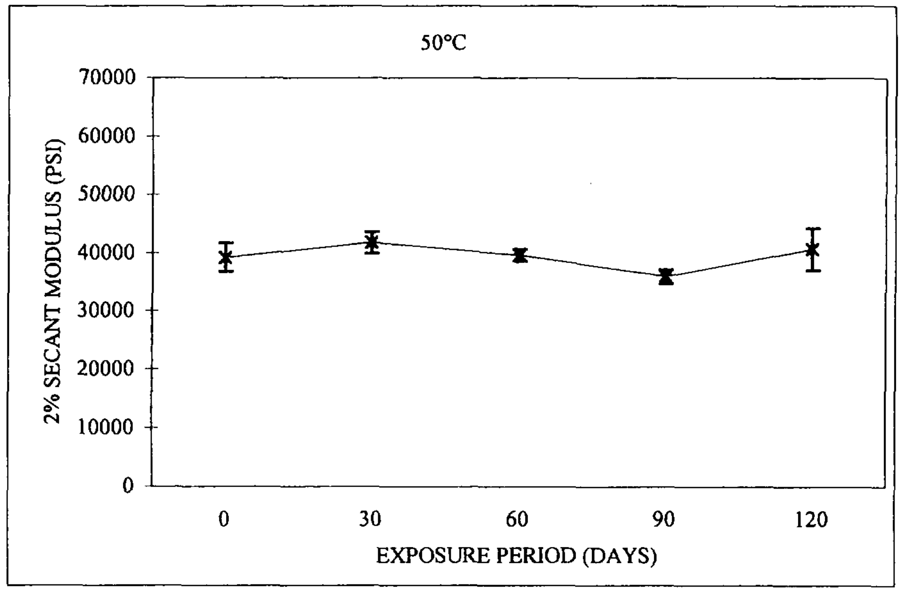
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): 2% SECANT MODULUS [1] (PSI)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	40350	37060	39090	42760	36840	39220	2457.4	0.0	40350	37060	39090	42760	36840	39220	2457.4	0.0	
30	40620	40360	36740	36600		38580	2208.8	-1.6	42700	41710	43620	39320		41838	1850.7	6.7	
60	36530	36450	33640	43500		37530	4200.8	-4.3	38800	40030	40950	38840		39655	1034.9	1.1	
90	37190	39730	44160	34390		38868	4148.0	-0.9	37270	36900	34960	35100		36058	1197.4	-8.1	
120	36240	39960	44050	34840		38773	4128.8	-1.1	36970	38500	42740	44670		40720	3590.4	3.8	





Notes:
1. 2% secant modulus values are calculated based on the total cross-head displacement and a gauge length of 33 mm (1.3 in.).
2. Error bars represent one standard deviation at mean sample value.

MODULUS.SGI.xls

Reviewed by: [signature] Date: 12/28/00
Cuneyt Gokmen, Program Manager

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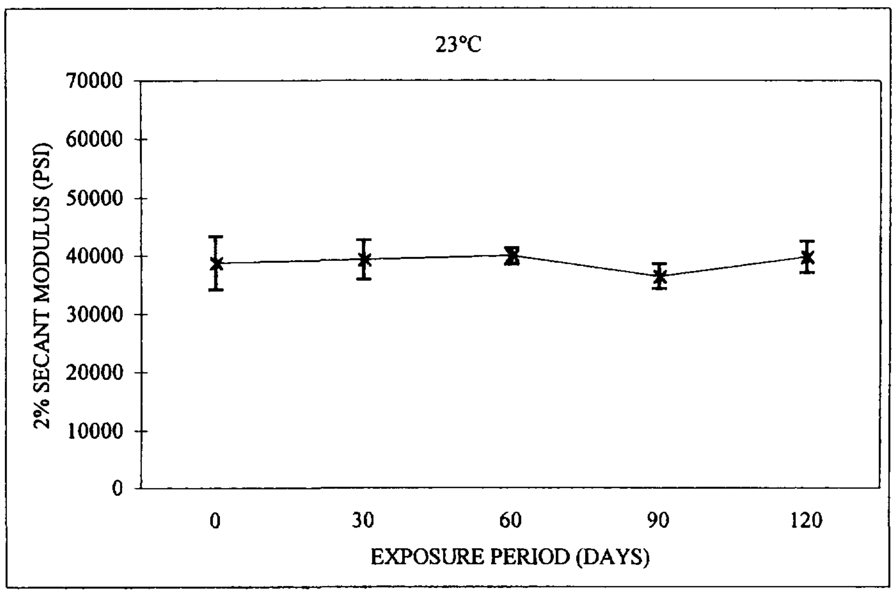
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

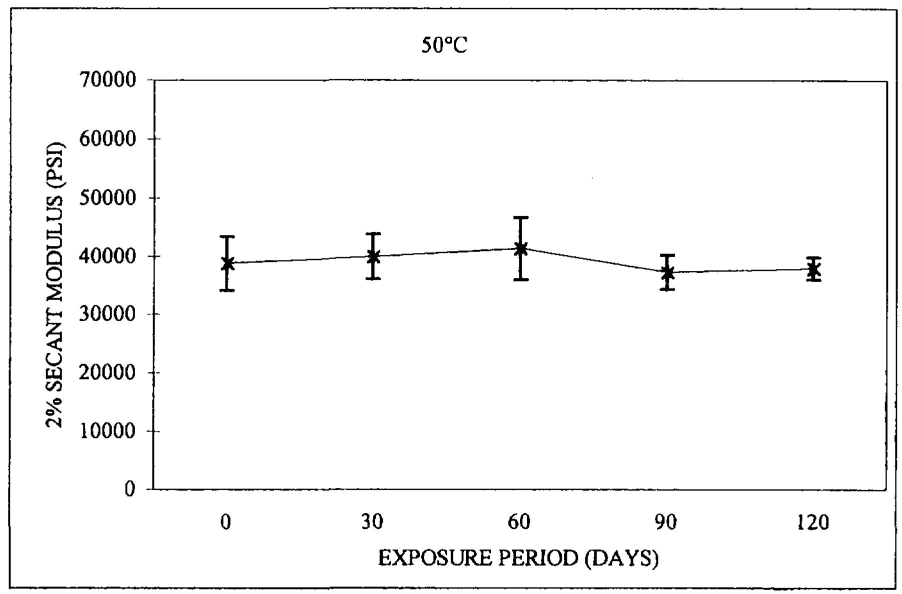
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 638

PROPERTY (UNIT): 2% SECANT MODULUS (1) (PSI)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	41390	39960	42760	30950	39080	38828	4621.5	0.0	41390	39960	42760	30950	39080	38828	4621.5	0.0	
30	34350	41390	40190	41490		39355	3388.5	1.4	35130	40040	40160	44670		40000	3896.7	3.0	
60	40160	37970	40650	41370		40038	1465.2	3.1	37170	36580	44220	47370		41335	5313.6	6.5	
90	36160	39380	34330	35920		36448	2116.9	-6.1	37710	38990	39590	33110		37350	2933.4	-3.8	
120	43130	37130	40760	38420		39860	2647.6	2.7	38940	40240	36450	36390		38005	1905.8	-2.1	





Notes:
1. 2% secant modulus values are calculated based on the total cross-head displacement and a gauge length of 33 mm (1.3 in.).
2. Error bars represent one standard deviation at mean sample value.

Reviewed by: [signature] Date: 12/28/00
Cuneyt Gokmen, Program Manager

MODULUS.SGI.xls

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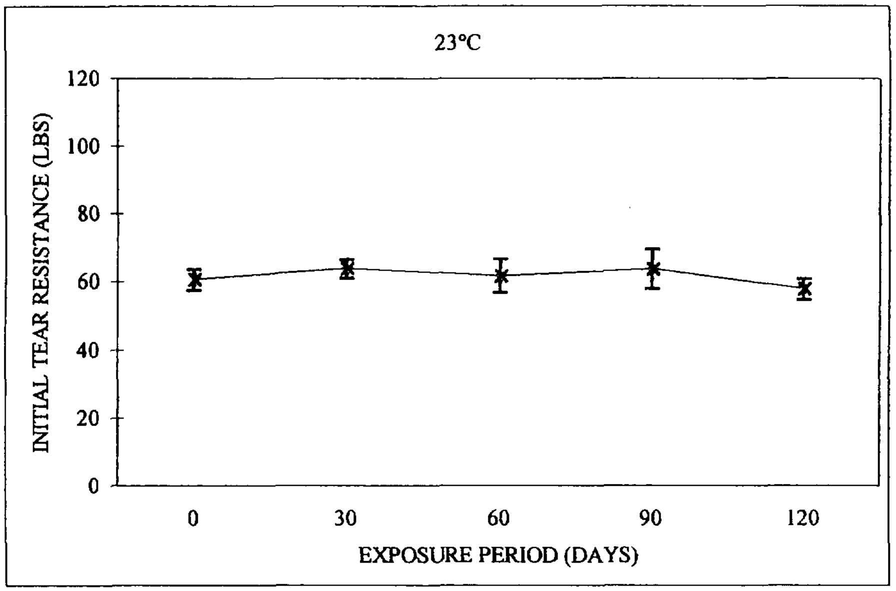
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

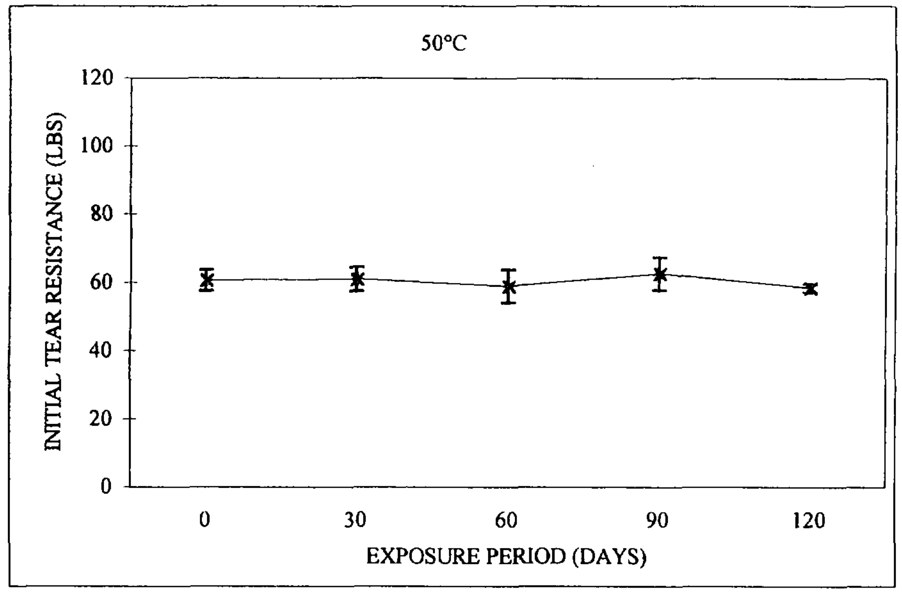
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 1004

PROPERTY (UNIT): INITIAL TEAR RESISTANCE (LBS)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	Specimens 2	Specimens 3	Specimens 4	Specimens 5	Mean	Standard Deviation	Percent Change	Specimens 1	Specimens 2	Specimens 3	Specimens 4	Specimens 5	Mean	Standard Deviation	Percent Change	
Control	62.0	63.1	59.3	56.0	63.3	60.7	3.1	0.0	62.0	63.1	59.3	56.0	63.3	60.7	3.1	0.0	
30	64.5	60.5	63.3	67.4		63.9	2.9	5.2	62.7	65.2	57.1	59.2		61.1	3.6	0.5	
60	65.5	65.7	55.2	60.5		61.7	5.0	1.6	59.4	61.6	51.9	62.9		59.0	4.9	-2.9	
90	61.2	66.9	69.9	56.8		63.7	5.8	4.9	57.5	66.2	67.5	59.9		62.8	4.8	3.4	
120	62.2	55.6	57.9	55.8		57.9	3.1	-4.7	56.6	59.1	59.1	59.6		58.6	1.4	-3.5	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/26/00
Cuneyt Gokmen, Program Manager

INITEAR.SGI.xls

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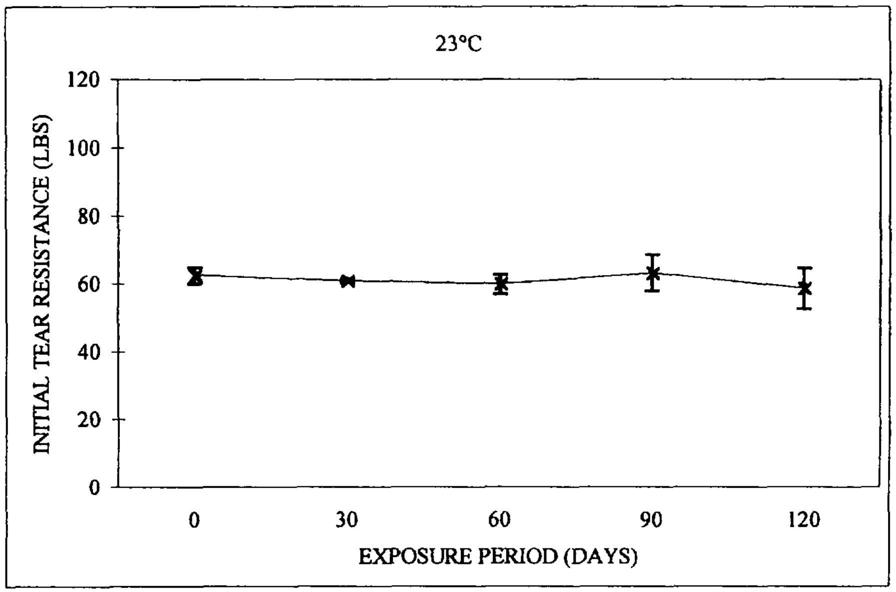
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

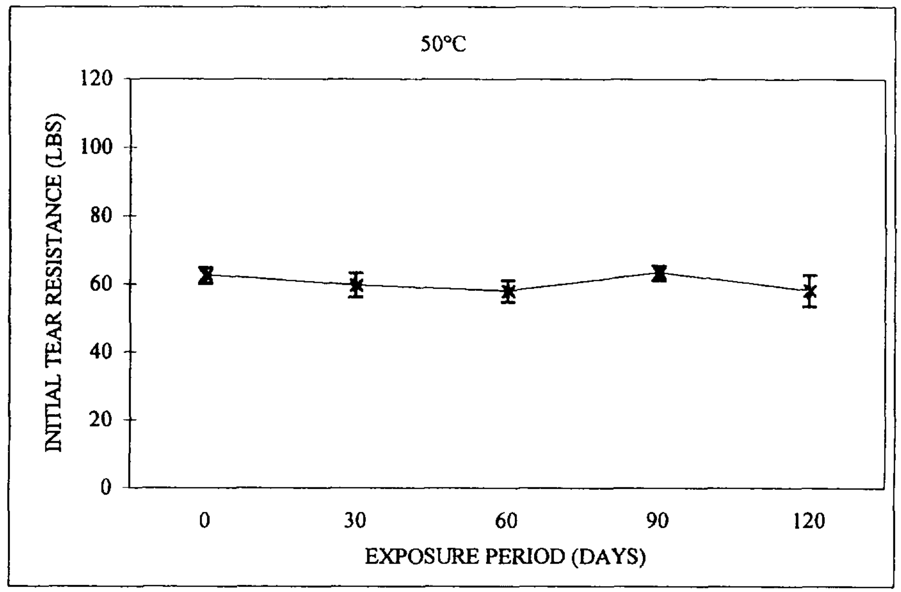
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 1004

PROPERTY (UNIT): INITIAL TEAR RESISTANCE (LBS)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	59.7	61.2	62.5	63.8	65.9	62.6	2.4	0.0	59.7	61.2	62.5	63.8	65.9	62.6	2.4	0.0	
30	61.6	60.6	61.5	60.3		61.0	0.6	-2.6	62.9	62.1	58.8	55.0		59.7	3.6	-4.7	
60	59.9	56.3	60.1	63.4		59.9	2.9	-4.3	57.2	62.7	55.4	56.8		58.0	3.2	-7.3	
90	63.8	70.5	58.6	60.2		63.3	5.3	1.0	65.0	63.0	60.5	65.1		63.4	2.2	1.2	
120	55.0	67.5	57.0	55.1		58.7	6.0	-6.3	54.9	64.0	54.3	59.5		58.2	4.5	-7.1	





Notes:
1. Break elongation values are calculated based on a gauge length of 50 mm (1.97 in.)
2. Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/26/00
Cuneyt Gokmen, Program Manager

INITEAR.SGI.xls

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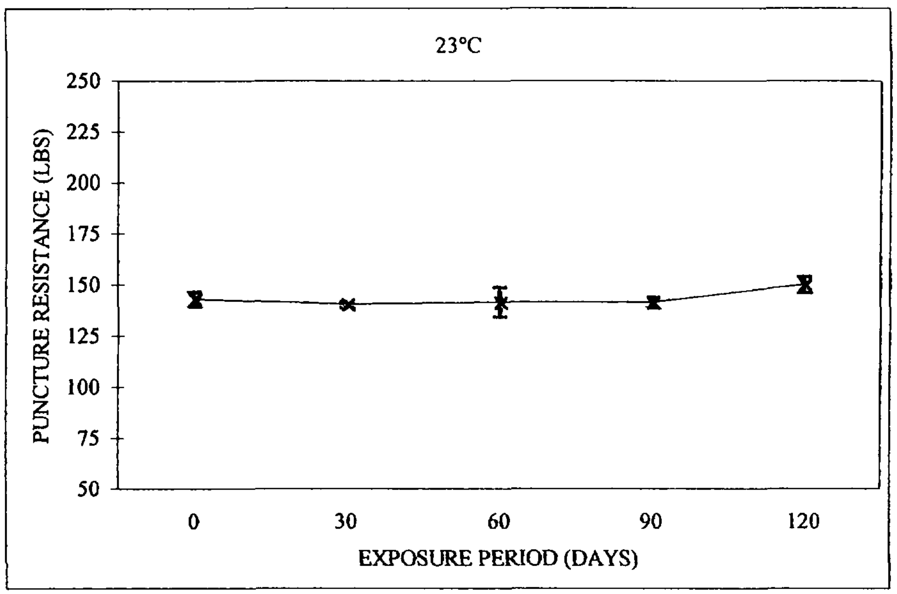
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

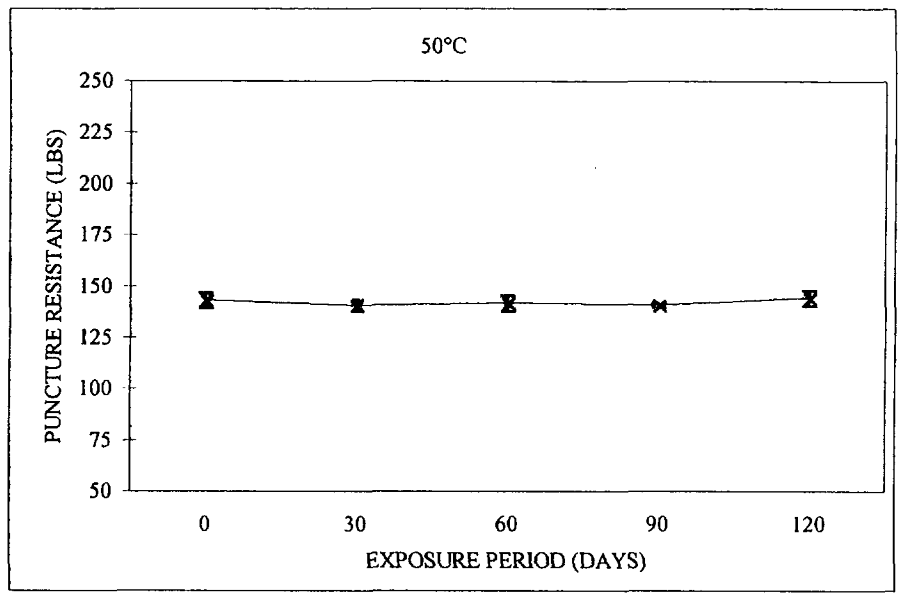
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 4833

PROPERTY (UNIT): INDEX PUNCTURE RESISTANCE (LBS)
DIRECTION: N/A

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	147.2	146.3	143.5	138.4	140.9	143.26	3.67	0.0	147.2	146.3	143.5	138.4	140.9	143.26	3.67	0.0	
30	138.7	141.1	141.8	140.5		140.53	1.33	-1.9	140.3	144.5	137.6	140.6		140.75	2.84	-1.8	
60	132.1	140.2	146.3	147.7		141.58	7.11	-1.2	146.8	141.8	141.6	137.5		141.93	3.81	-0.9	
90	142.7	138.4	144.5	141.1		141.68	2.59	-1.1	141.5	141.8	139.7	141.4		141.10	0.95	-1.5	
120	155.9	150.7	148.4	146.3		150.33	4.13	4.9	147.5	143.2	147.7	139.7		144.53	3.83	0.9	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: [signature] Date: 12/21/00
Cuneyt Gokmen, Program Manager

PUNCTURE.SGI.xls

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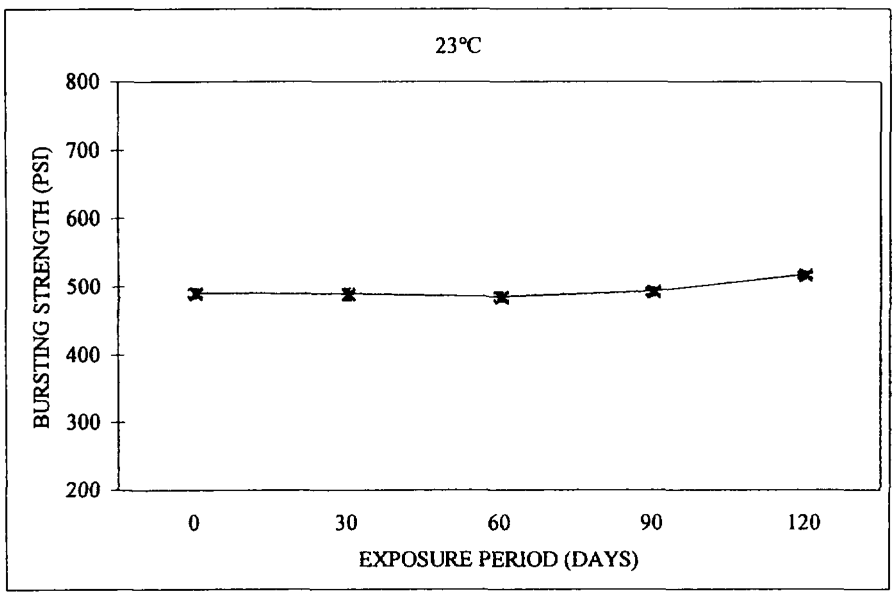
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

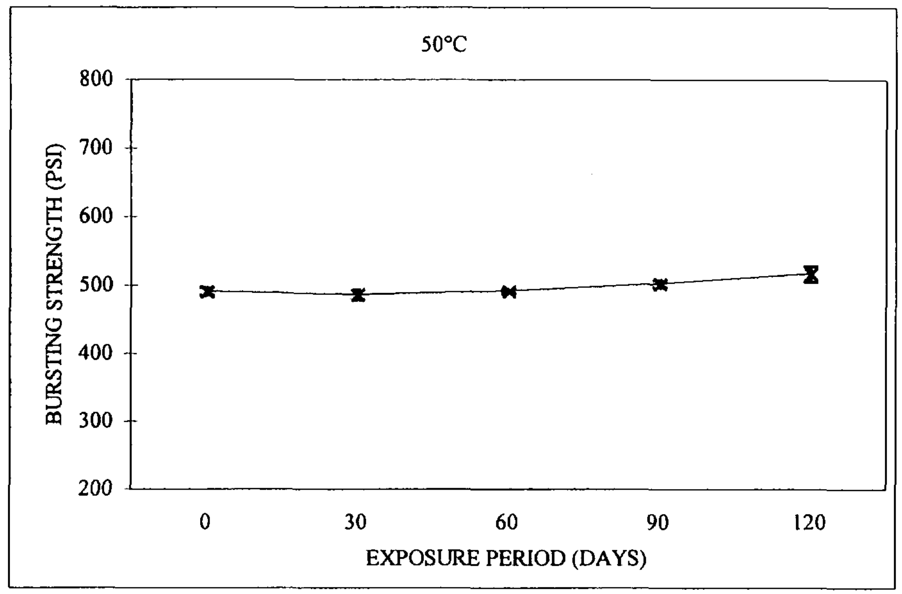
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 60 MIL HDPE SMOOTH GEOMEMBRANE
CLIENT SAMPLE ID: GSE 60 MIL HYPERFLEX
GEOSYNTEC SAMPLE NO: AL7853
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 3786

PROPERTY (UNIT): HYDRAULIC BURSTING STRENGTH (PSI)
DIRECTION: N/A

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	501	489	490	486	489	491.0	5.8	0.0	501	489	490	486	489	491.0	5.8	0.0	
30	483	482	494	498		489.3	8.0	-0.4	488	485	478	495		486.5	7.0	-0.9	
60	494	480	485	482		485.3	6.2	-1.2	495	489	491	493		492.0	2.6	0.2	
90	497	498	489	488		493.0	5.2	0.4	510	504	501	497		503.0	5.5	2.4	
120	518	518	512	522		517.5	4.1	5.4	519	529	502	521		518	11.4	5.4	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: [signature] Date: 12/21/00
Cuneyt Gokmen, Program Manager

BURST.SGI.xls

GEOTEXTILE

GEOSYNTEC CONSULTANTS
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Ph: (404) 705 9500 Fax: (404) 705 9300

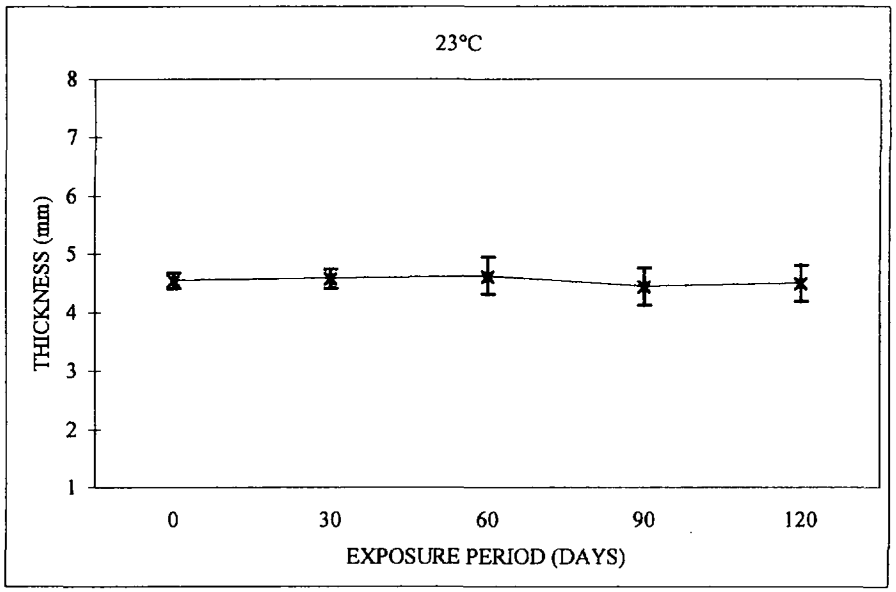
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

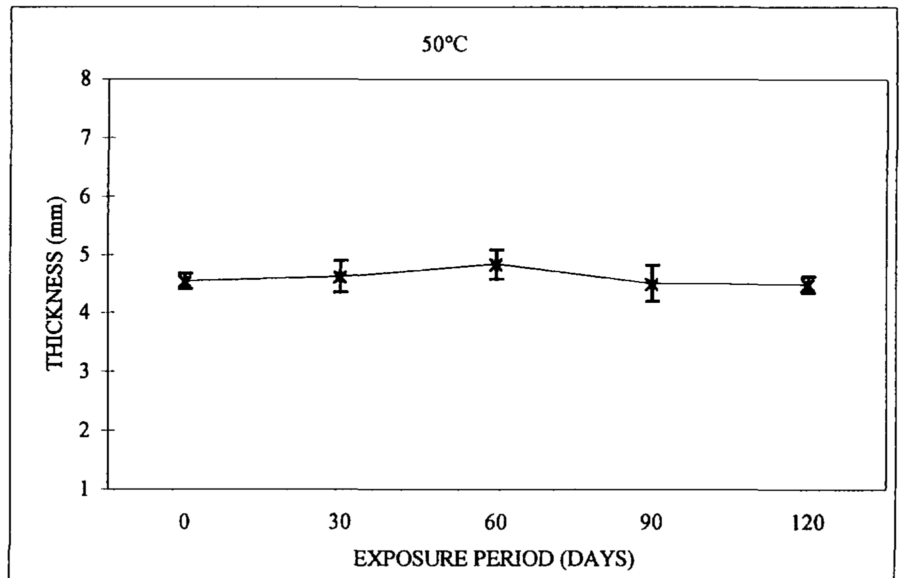
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 5199

PROPERTY (UNIT): THICKNESS (mm)
DIRECTION: N/A

Exposure Period (Days)	23°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	50°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Remarks
Control	4.58	4.41	4.73	4.49		4.55	0.14	0.0	4.58	4.41	4.73	4.49		4.55	0.14	0.0	
30	4.60	4.82	4.48	4.43		4.58	0.17	0.7	4.51	5.01	4.62	4.38		4.63	0.27	1.7	
60	4.85	4.22	4.51	4.92		4.63	0.32	1.6	4.82	5.00	4.49	5.04		4.84	0.25	6.3	
90	4.48	4.02	4.46	4.81		4.44	0.32	-2.4	4.80	4.11	4.42	4.71		4.51	0.31	-0.9	
120	4.14	4.38	4.87	4.59		4.50	0.31	-1.3	4.31	4.65	4.54	4.47		4.49	0.14	-1.3	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

THICKNESS.SGI.xls

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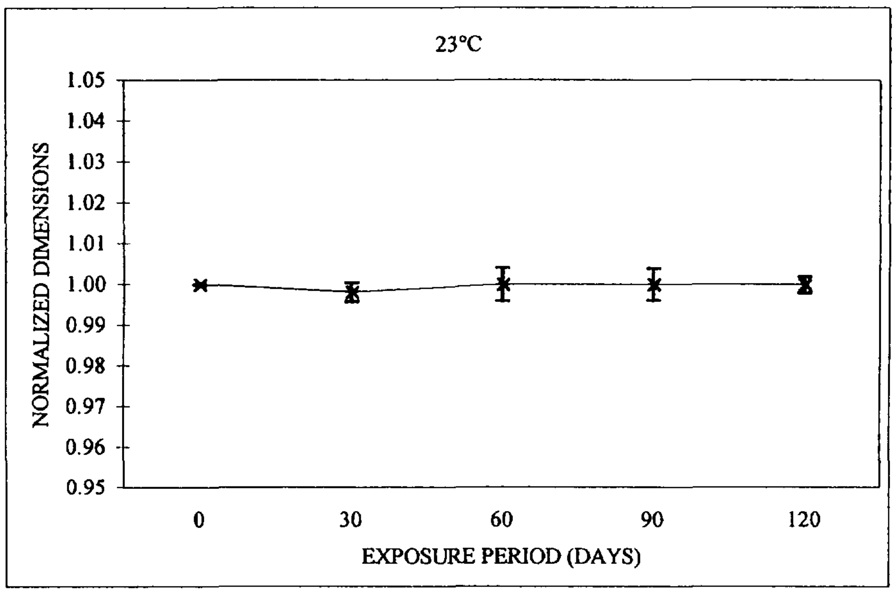
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

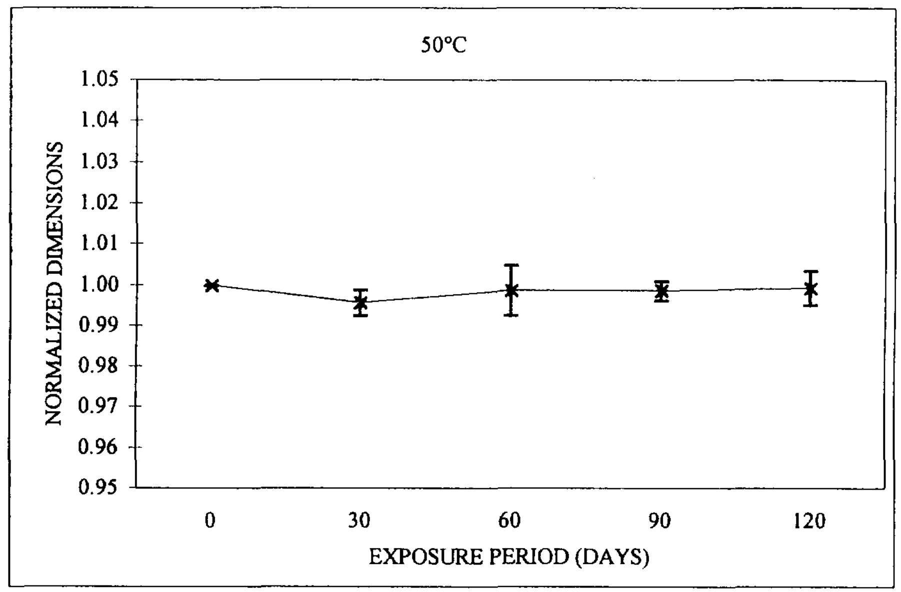
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: EPA 9090

PROPERTY (UNIT): NORMALIZED DIMENSIONS (FINAL LENGTH/INITIAL LENGTH)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C									Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change		
Control	1.0000	1.0000	1.0000	1.0000		1.0000	0.0000	0.00	1.0000	1.0000	1.0000	1.0000		1.0000	0.0000	0.00		
30	1.0000	0.9951	1.0000	0.9975		0.9982	0.0024	-0.19	0.9951	0.9951	1.0000	0.9927		0.9957	0.0031	-0.43		
60	1.0000	1.0050	0.9951	1.0000		1.0000	0.0040	0.00	0.9901	1.0000	1.0000	1.0049		0.9988	0.0062	-0.12		
90	1.0000	0.9951	1.0000	1.0049		1.0000	0.0040	0.00	1.0000	1.0000	1.0000	0.9951		0.9988	0.0025	-0.12		
120	1.0000	1.0000	1.0025	0.9976		1.0000	0.0020	0.00	1.0049	1.0000	0.9951	0.9976		0.9994	0.0042	-0.06		





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

DIMENSIONS.SGI.xls

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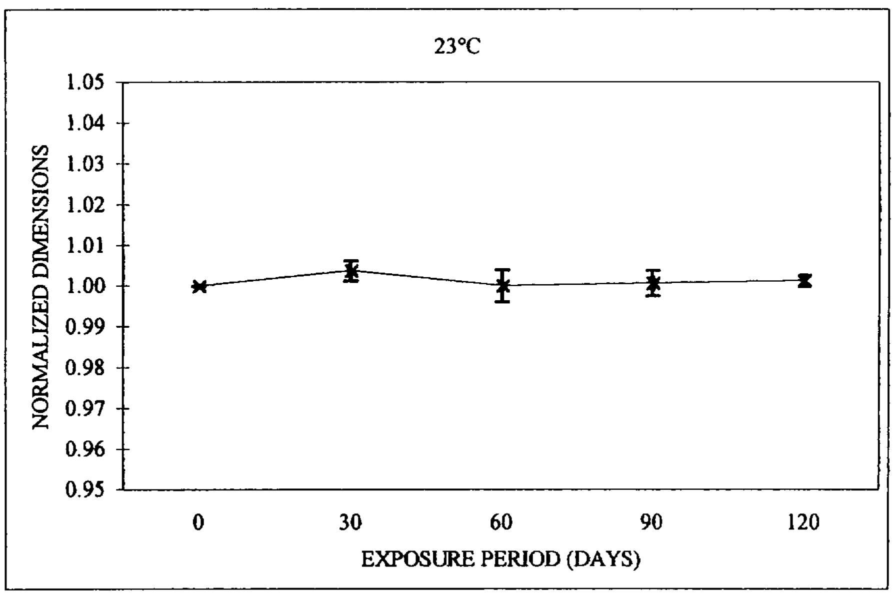
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

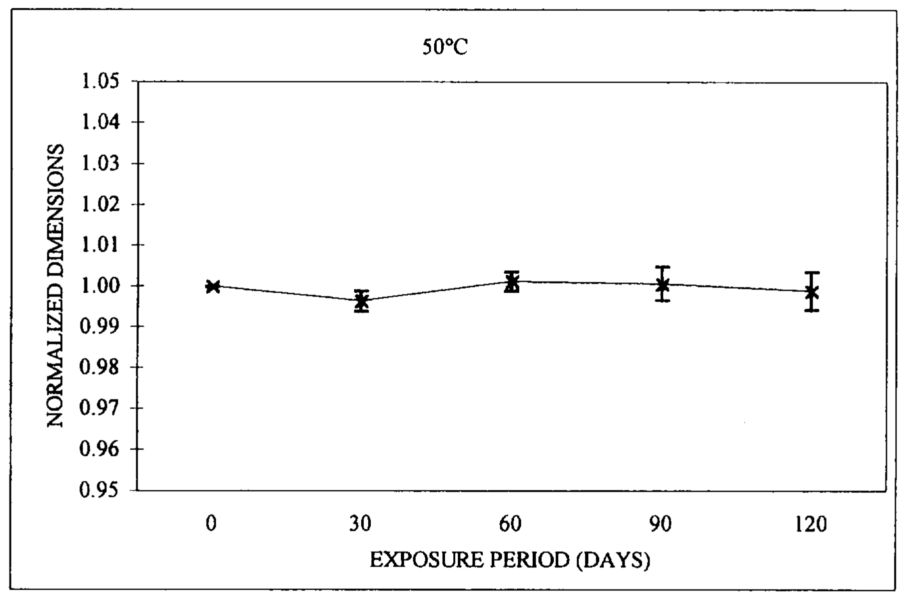
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: EPA 9090

PROPERTY (UNIT): NORMALIZED DIMENSIONS (FINAL LENGTH/INITIAL LENGTH)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	1.0000	1.0000	1.0000	1.0000		1.0000	0.0000	0.00	1.0000	1.0000	1.0000	1.0000		1.0000	0.0000	0.00	
30	1.0050	1.0050	1.0000	1.0049		1.0037	0.0025	0.37	1.0000	0.9951	0.9951	0.9951		0.9963	0.0025	-0.37	
60	1.0000	1.0000	1.0049	0.9951		1.0000	0.0040	0.00	1.0000	1.0049	1.0000	1.0000		1.0012	0.0024	0.12	
90	1.0000	0.9976	1.0049	1.0000		1.0006	0.0031	0.06	0.9951	1.0049	1.0000	1.0024		1.0006	0.0042	0.06	
120	1.0025	1.0000	1.0025	1.0000		1.0012	0.0014	0.12	1.0000	0.9952	0.9951	1.0049		0.9988	0.0047	-0.12	





Note: Error bars represent one standard deviation at mean sample value.

DIMENSIONS.SGI.xls

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

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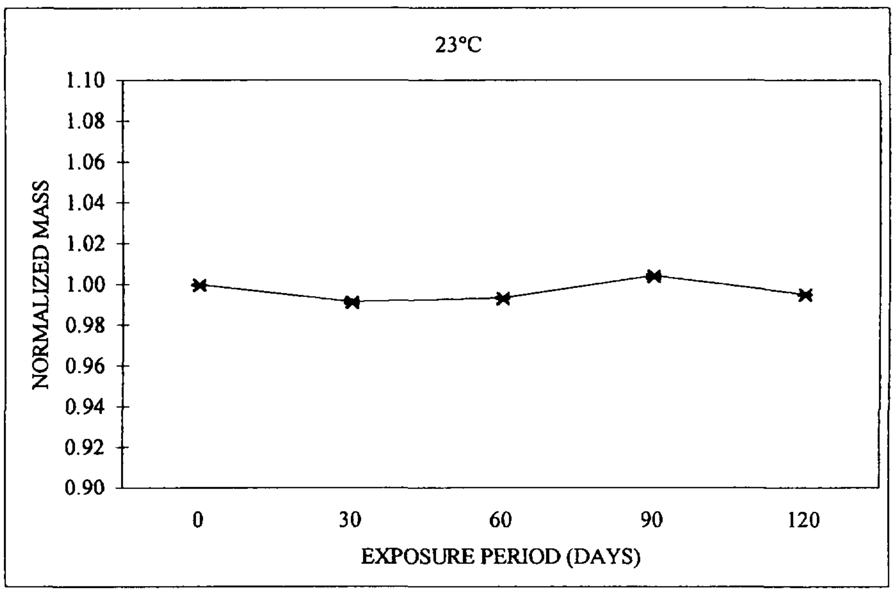
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

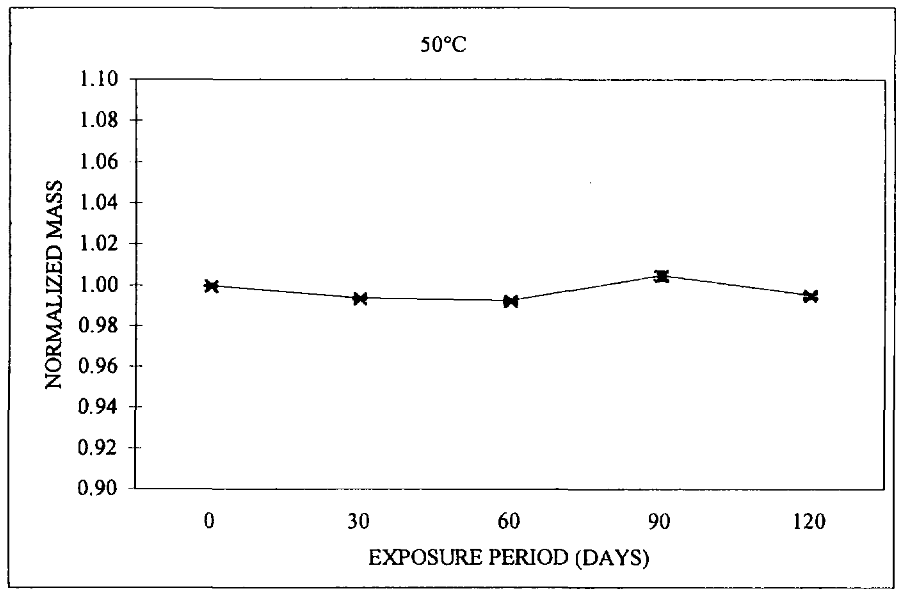
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: EPA 9090

PROPERTY (UNIT): NORMALIZED MASS (FINAL MASS/INITIAL MASS)
DIRECTION: N/A

Exposure Period (Days)	23°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	50°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Remarks
Control	1.0000	1.0000				1.0000	0.0000	0.00	1.0000	1.0000				1.0000	0.0000	0.00	
30	0.9911	0.9923				0.9917	0.0008	-0.83	0.9936	0.9942				0.9939	0.0004	-0.61	
60	0.9934	0.9938				0.9936	0.0003	-0.64	0.9933	0.9920				0.9927	0.0010	-0.73	
90	1.0036	1.0049				1.0042	0.0009	0.42	1.0035	1.0066				1.0051	0.0022	0.51	
120	0.9952	0.9953				0.9952	0.0000	-0.48	0.9961	0.9946				0.9953	0.0011	-0.47	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

MASS.SGI.xls

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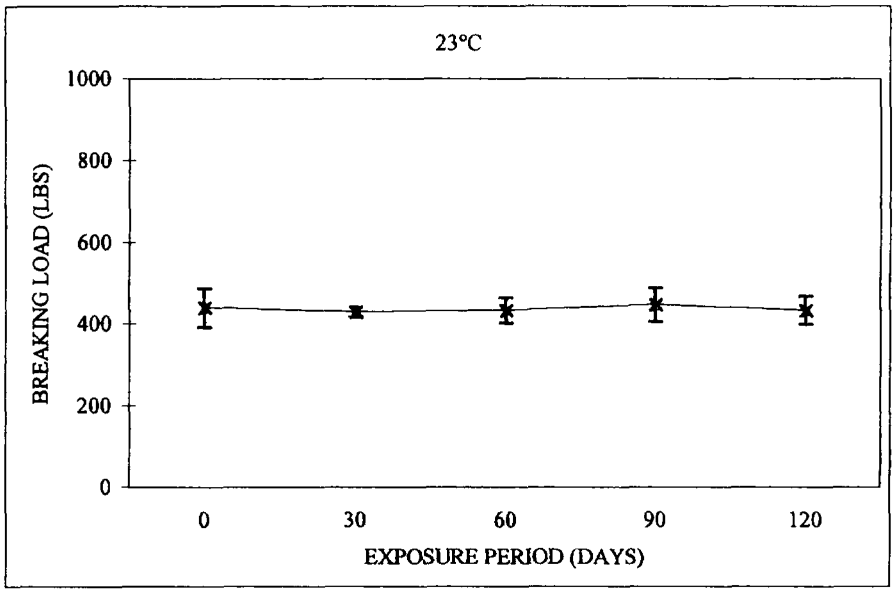
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

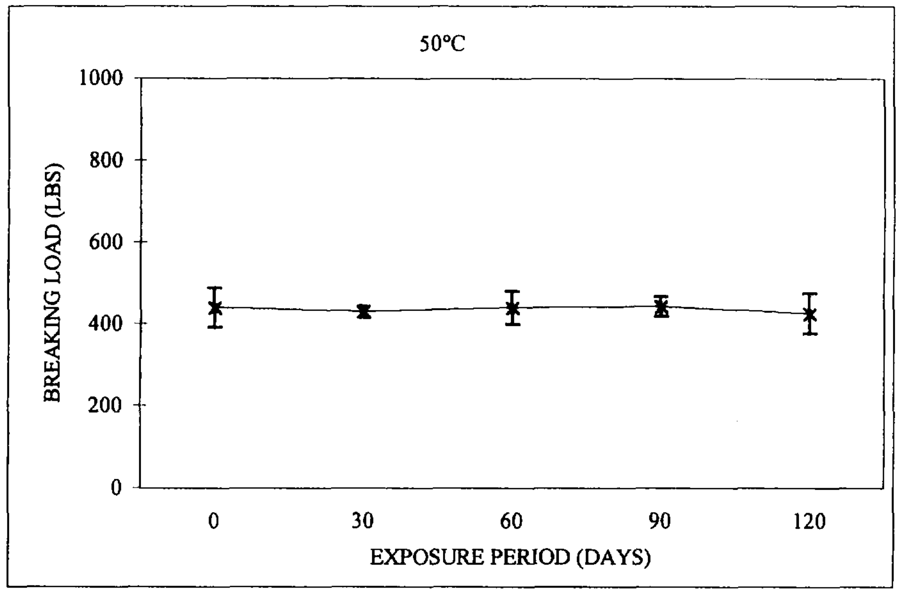
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 4632

PROPERTY (UNIT): GRAB BREAKING LOAD (LBS)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	470.2	392.7	384.5	460.2	492.0	439.9	48.3	0.0	470.2	392.7	384.5	460.2	492.0	439.9	48.3	0.0	
30	422.0	424.5	444.7			430.4	12.4	-2.2	429.0	445.5	418.7			431.1	13.5	-2.0	
60	399.7	436.1	462.4			432.7	31.5	-1.6	408.5	425.2	485.5			439.7	40.5	0.0	
90	412.7	432.4	493.2			446.1	42.0	1.4	447.9	465.6	417.6			443.7	24.3	0.9	
120	473.1	412.7	413.4			433.1	34.7	-1.6	412.8	480.9	385.4			426.4	49.2	-3.1	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 1/2/01
Cuneyt Gokmen, Program Manager

GRABSTRS.SGI.xls

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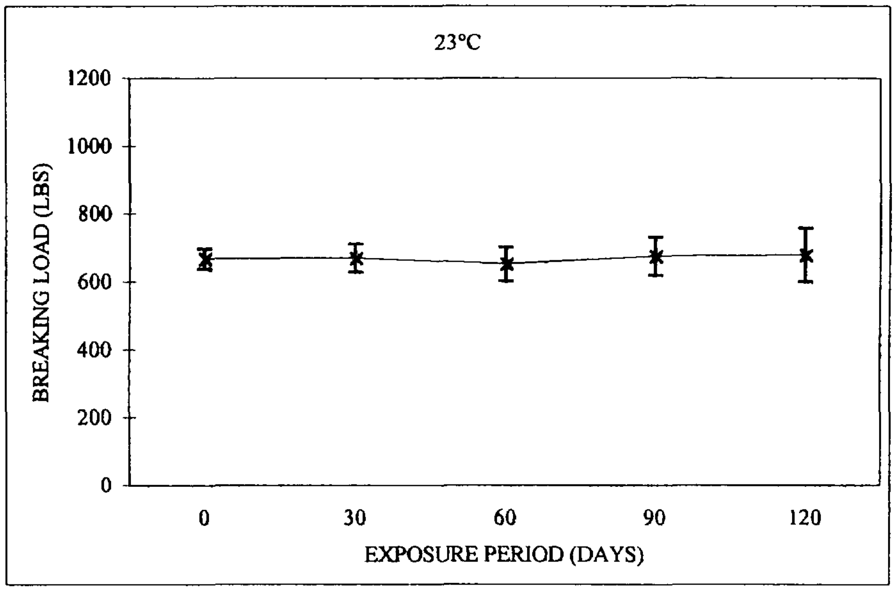
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

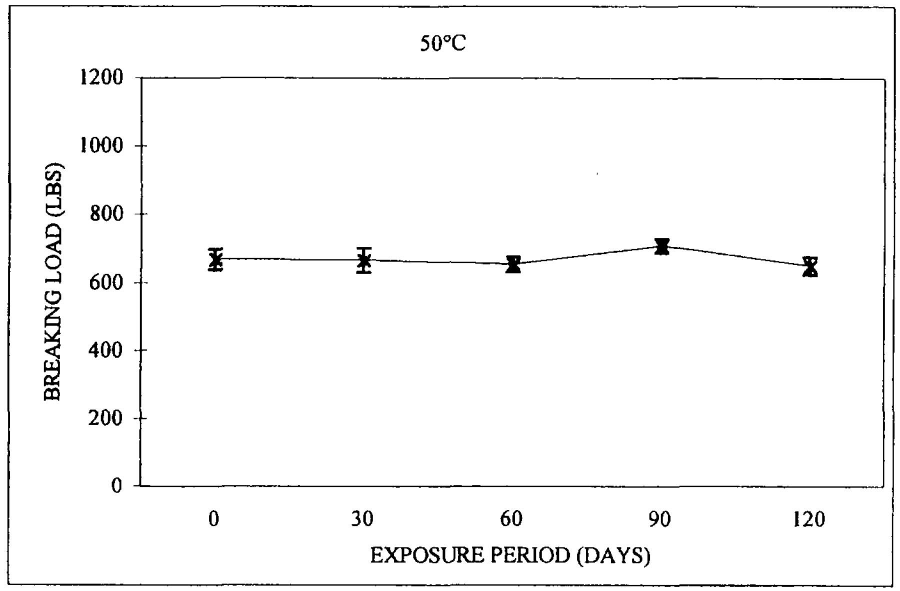
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 4632

PROPERTY (UNIT): GRAB BREAKING LOAD (LBS)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	679.7	673.7	679.0	618.0	698.5	669.8	30.4	0.0	679.7	673.7	679.0	618.0	698.5	669.8	30.4	0.0	
30	716.0	637.0	661.0			671.3	40.5	0.2	633.7	667.2	703.5			668.1	34.9	-0.2	
60	613.7	709.2	638.0			653.6	49.6	-2.4	680.7	652.5	636.7			656.6	22.3	-2.0	
90	632.8	656.2	740.8			676.6	56.8	1.0	690.4	728.8	715.4			711.5	19.5	6.2	
120	589.2	729.0	723.4			680.5	79.1	1.6	682.7	645.9	630.4			653.0	26.9	-2.5	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/27/00
Cuneyt Gokmen, Program Manager

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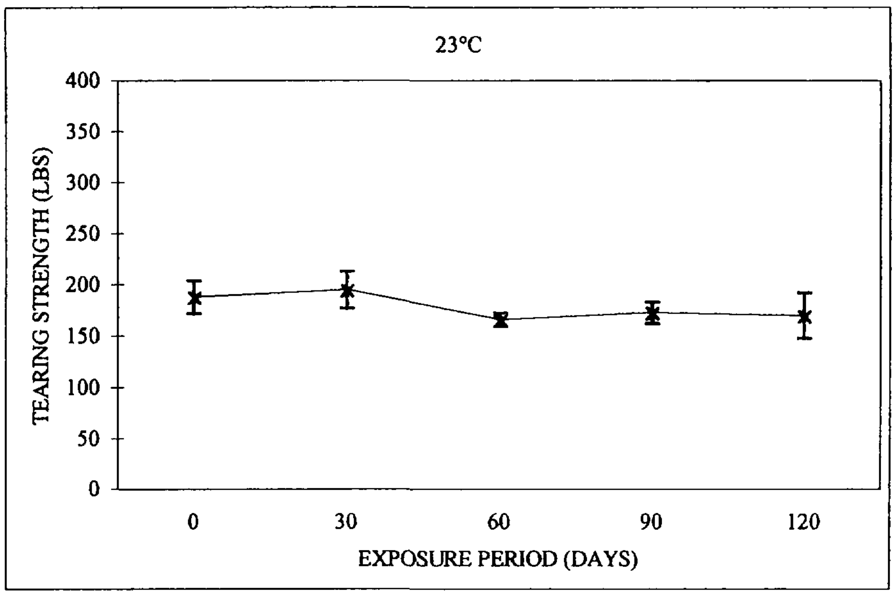
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

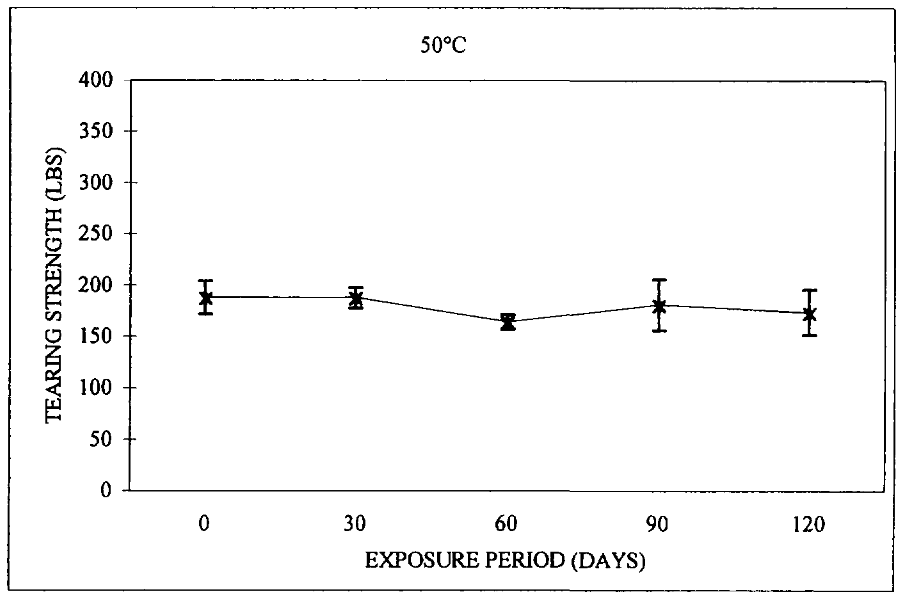
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 4533

PROPERTY (UNIT): TRAPEZOID TEARING STRENGTH (LBS)
DIRECTION: ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	174.2	184.0	210.0	198.7	172.5	187.9	16.2	0.0	174.2	184.0	210.0	198.7	172.5	187.9	16.2	0.0	
30	187.1	215.5	182.5			195.0	17.9	3.8	197.1	189.6	177.1			187.9	10.1	0.0	
60	168.2	158.5	170.7			165.8	6.4	-11.8	172.2	158.5	162.5			164.4	7.0	-12.5	
90	164.2	184.5	169.0			172.6	10.6	-8.2	200.5	190.2	153.2			181.3	24.9	-3.5	
120	173.5	189.4	146.1			169.7	21.9	-9.7	188.0	185.0	148.1			173.7	22.2	-7.5	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/27/00
Cuneyt Gokmen, Program Manager

TRAP.SGI.xls

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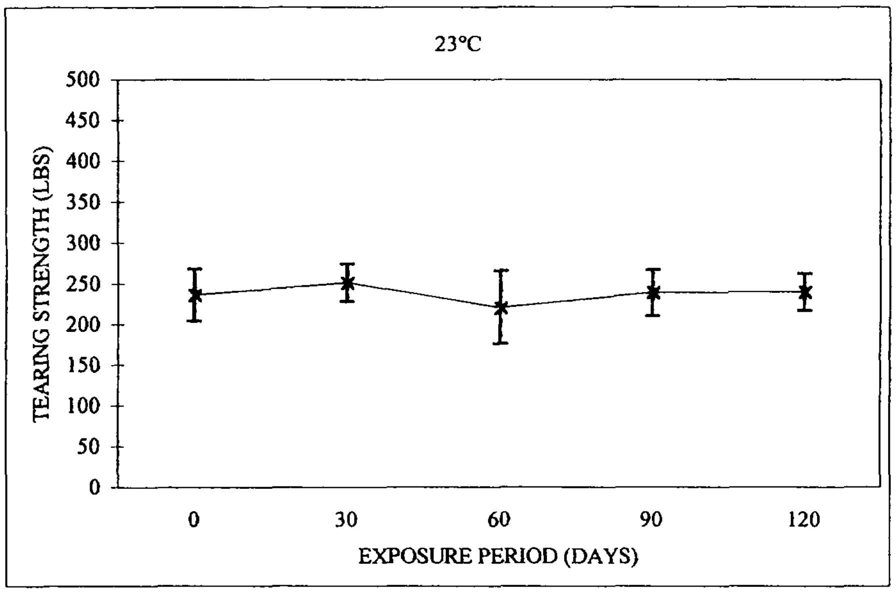
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

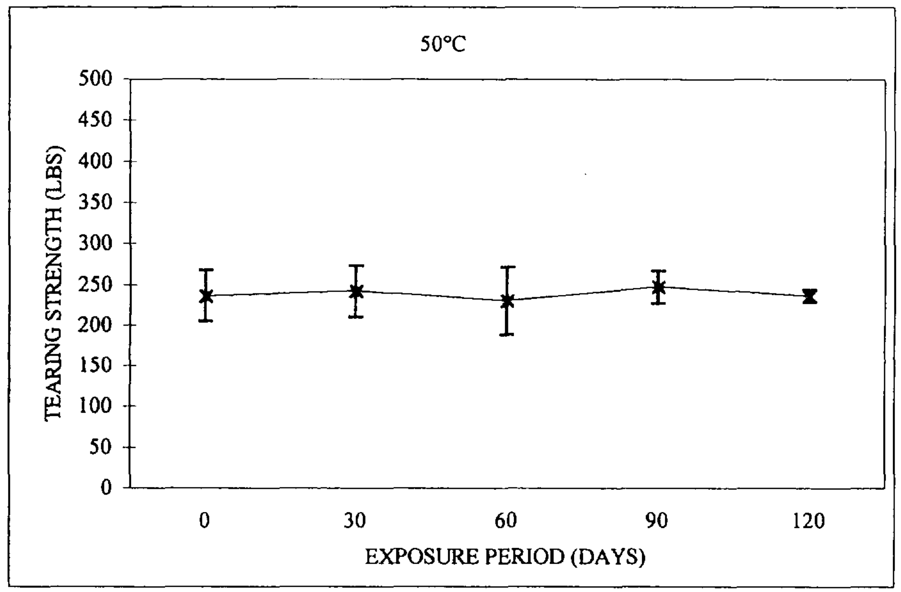
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 4533

PROPERTY (UNIT): TRAPEZOID TEARING STRENGTH (LBS)
DIRECTION: CROSS-ROLL

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	207.0	262.5	233.0	205.6	275.6	236.7	31.8	0.0	207.0	262.5	233.0	205.6	275.6	236.7	31.8	0.0	
30	225.5	265.8	264.3			251.9	22.8	6.4	238.3	213.1	275.5			242.3	31.4	2.3	
60	270.0	212.2	181.7			221.3	44.8	-6.5	190.0	273.0	229.5			230.8	41.5	-2.5	
90	233.3	214.5	270.7			239.5	28.6	1.2	262.6	255.7	224.8			247.7	20.1	4.6	
120	239.8	264.0	218.0			240.6	23.0	1.6	241.2	242.6	228.8			237.5	7.6	0.3	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/27/00
Cuneyt Gokmen, Program Manager

TRAP.SGI.xls

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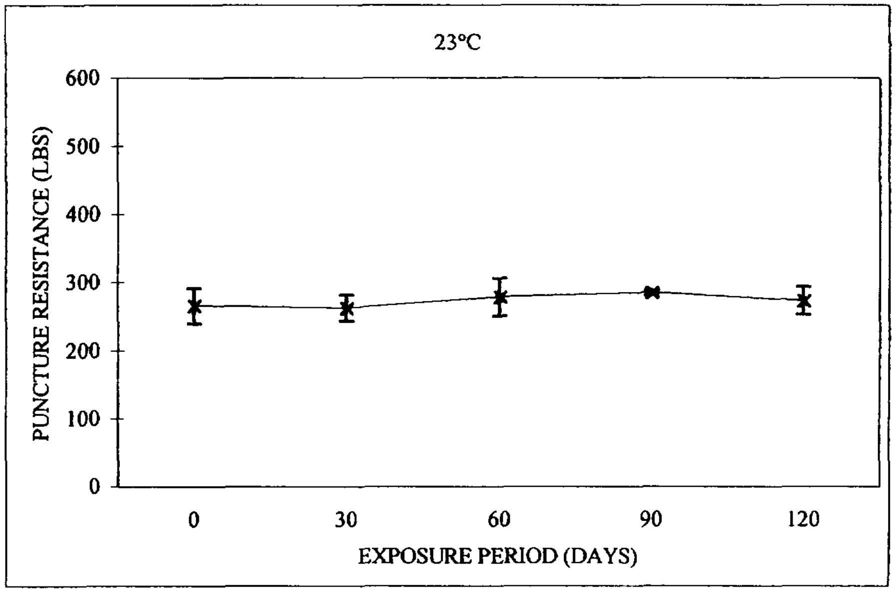
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

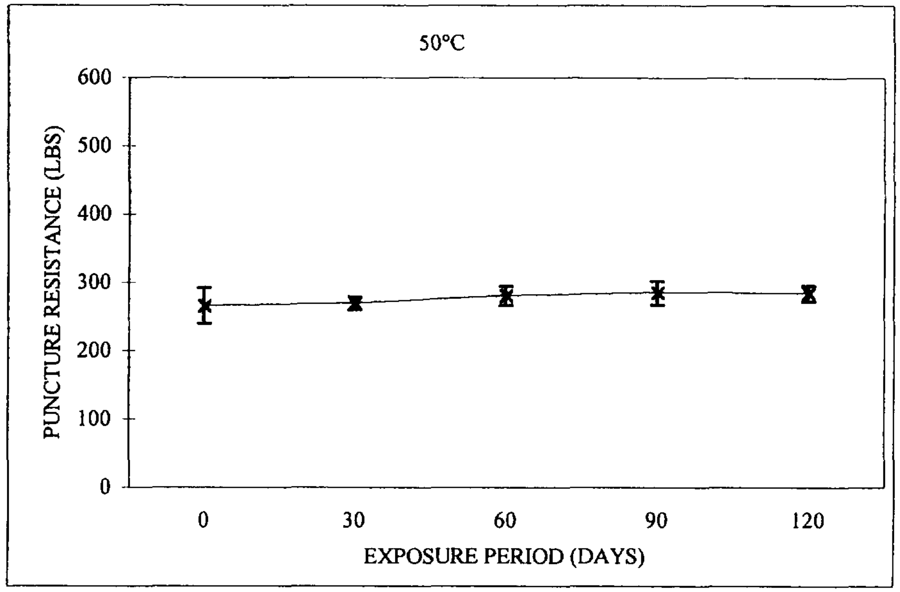
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 4833

PROPERTY (UNIT): INDEX PUNCTURE RESISTANCE (LBS)
DIRECTION: N/A

Exposure Period (Days)	23°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	50°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Remarks
Control	235.1	274.1	303.4	249.6	267.6	265.96	25.94	0.0	235.1	274.1	303.4	249.6	267.6	265.96	25.94	0.0	
30	245.6	247.8	271.3	285.8		262.63	19.34	-1.3	282.2	266.3	268.5	260.6		269.40	9.16	1.3	
60	319.3	264.2	259.2	270.3		278.25	27.74	4.6	287.5	259.7	284.9	290.6		280.68	14.18	5.5	
90	287.2	287.5	279.6	285.4		284.93	3.67	7.1	305.2	292.4	268.5	274.2		285.08	16.85	7.2	
120	267.6	297.7	277.4	250.1		273.20	19.86	2.7	277.4	283.5	301.3	274.7		284.23	11.96	6.9	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

PUNCTURE.SGI.xls

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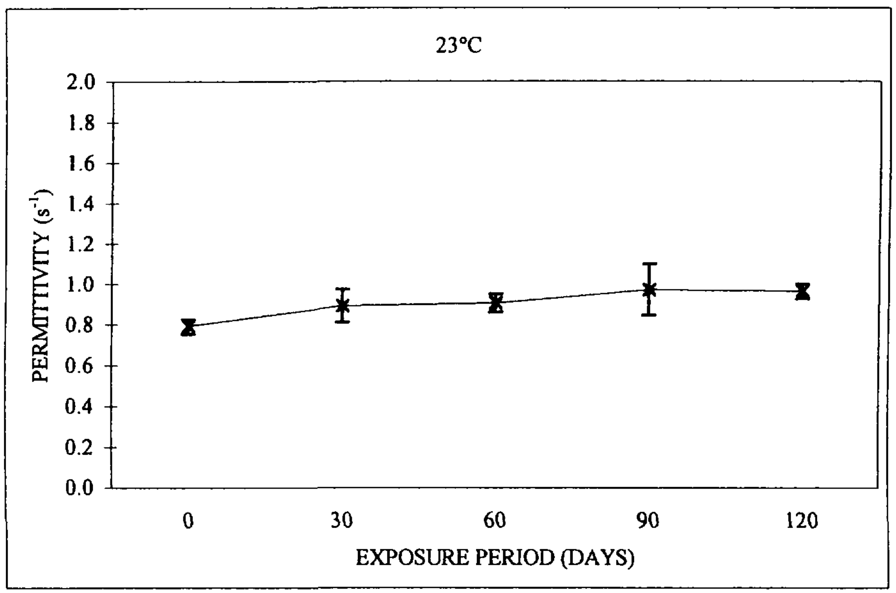
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

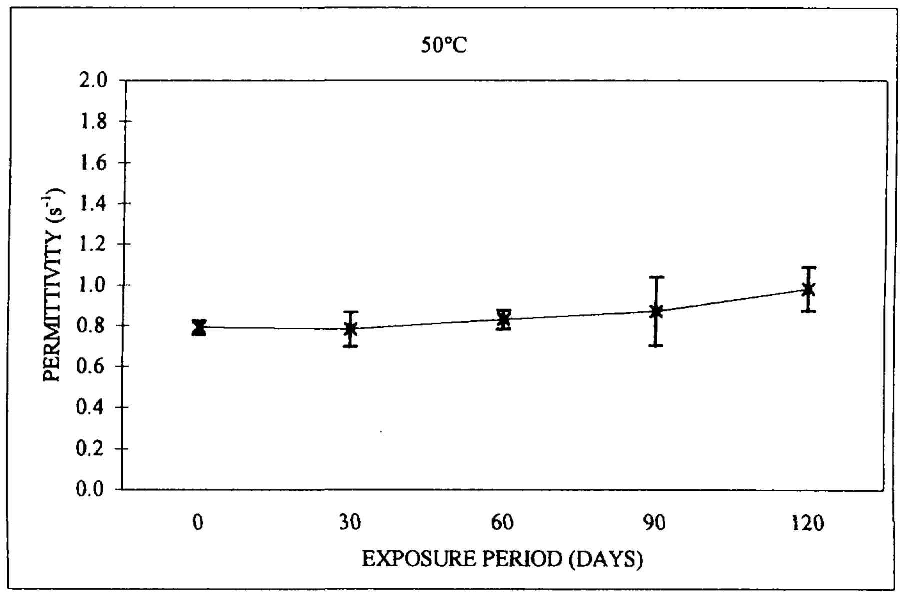
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GL11096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 4491 (1)

PROPERTY (UNIT): PERMITTIVITY (s^{-1})
DIRECTION: N/A

Exposure Period (Days)	23°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	50°C Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Remarks
Control	0.75	0.81	0.78	0.83		0.79	0.04	0.0	0.75	0.81	0.78	0.83		0.79	0.04	0.0	
30	0.94	0.94	0.80			0.89	0.08	12.7	0.85	0.81	0.69			0.78	0.08	-1.2	
60	0.86	0.91	0.95			0.91	0.05	14.4	0.78	0.87	0.85			0.83	0.05	5.2	
90	1.02	0.83	1.07			0.97	0.13	22.8	0.91	0.69	1.02			0.87	0.17	10.2	
120	1.00	0.97	0.93			0.97	0.04	22.0	1.10	0.96	0.89			0.98	0.11	24.1	





Notes:
1. Permittivity tests were performed at 0.5-in. water head across the specimen.
2. Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/28/00
Cuneyt Gokmen, Program Manager

PERMITTIVITY.SGI.xls

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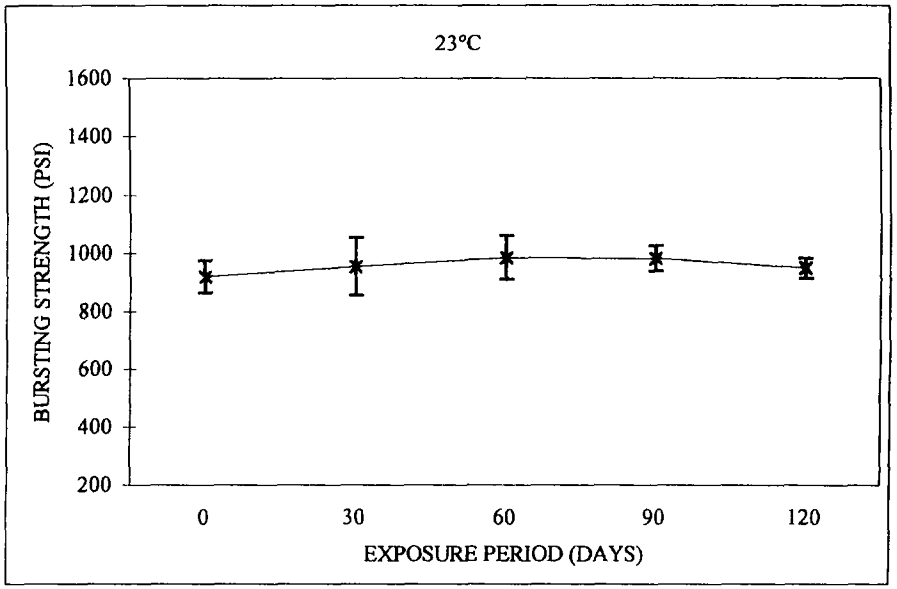
CHEMICAL COMPATIBILITY TEST RESULTS
EPA METHOD 9090

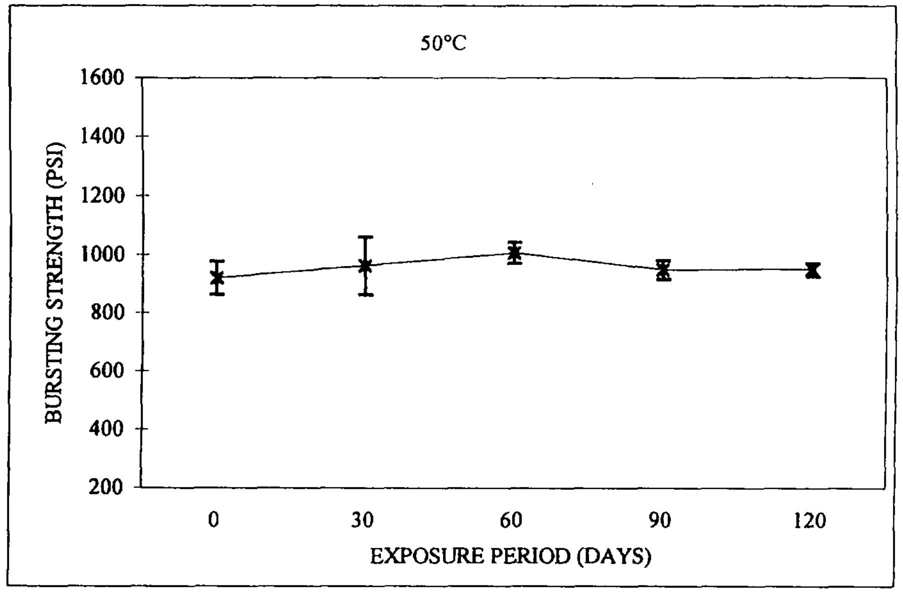
CLIENT: URS GREINER WOODWARD CLYDE
CLIENT PROJECT NO: C100003899.00
CONTACT: GARY M. WANTLAND, P.E.
PROJECT NAME: SAUGET AREA 1 TSCA LANDFILL
GEOSYNTEC JOB NO: GLI1096

MATERIAL TYPE: 16 OZ. PP NONWOVEN GEOTEXTILE
CLIENT SAMPLE ID: SYNTHETIC INDUSTRIES 16 OZ. NONWOVEN
GEOSYNTEC SAMPLE NO: AL7890
IMMERSION MEDIUM: PROJECT SPECIFIC SYNTHETIC LEACHATE
TEST STANDARD: ASTM D 3786

PROPERTY (UNIT): HYDRAULIC BURSTING STRENGTH (PSI)
DIRECTION: N/A

Exposure Period (Days)	23°C								50°C								Remarks
	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	Specimens 1	2	3	4	5	Mean	Standard Deviation	Percent Change	
Control	1004	845	919	913	921	920.4	56.4	0.0	1004	845	919	913	921	920.4	56.4	0.0	
30	1104	900	901	916		955.3	99.4	3.8	937	960	858	1092		961.8	97.2	4.5	
60	1015	892	969	1069		986.3	75.0	7.2	1027	1022	1025	952		1006.5	36.4	9.4	
90	990	919	1004	1017		982.5	43.7	6.7	934	921	943	997		948.8	33.4	3.1	
120	926	977	915	984		950.5	35.0	3.3	951	919	970	964		951.0	22.8	3.3	





Note: Error bars represent one standard deviation at mean sample value.

Reviewed by: Date: 12/21/00
Cuneyt Gokmen, Program Manager

BURST.SGI.xls